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Original Article

Correlation analysis between diseases and blood component utilization in different ABO blood groups

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ABSTRACT

This study aims to investigate the relationship between ABO blood group, blood component usage, and various diseases to enhance clinical blood preparation and transfusion efficacy. A comprehensive analysis was conducted on data of patients who were hospitalized and received transfusions at the Third Xiangya Hospital of Central South University from 2021 to 2023. The results indicated significant variations in ABO blood group distribution among various departments. Group A was predominant in gynecology (34.53%) and hepatobiliary surgery (35.60%), while group O was found to be the most frequent blood type in obstetrics (34.97%) and urology (34.53%). Blood component usage was also correlated with diseases: red blood cell (RBC) transfusions were predominantly administered to cancer patients (12.76%), liver disease patients receiving the highest amount of frozen plasma (FP) and cryoprecipitate (19.71%, 27.05%), and autoimmune hemolytic anemia patients receiving the highest amount of platelets (PLTs, 30.29%). Additionally, group O was more frequently used for RBCs (34.72%), FP (36.17%), and PLTs (36.84%), whereas group A showed predominant usage in RBCs (34.56%) and cryoprecipitate (34.21%). This study emphasizes the connection between ABO blood group, blood transfusion components, and diseases, providing valuable insights for clinical blood management.

Keywords: ABO blood group, correlation analysis, blood components

INTRODUCTION

Recent advancements in medical research and scientific technology have uncovered the molecular genetic basis of ABO blood group polymorphism. The relationship between this and diseases has also gathered significant interest[1]. Some researchers believe that polymorphisms observed in ABO blood group and other blood groups are the result of evolutionary selection mediated by environmental factors and pathogens, leading to an inevitable connection between ABO blood group and diseases[1–2]. Many studies have shown that individuals with varying blood groups exhibit differences in terms of disease risk, type, and clinical manifestations. Statistics show that people with group A have a higher likelihood of developing cancer compared to those with group O, particularly in the cases of gastric cancer, ovarian cancer, salivary gland cancer, cervical cancer, uterine cancer, and colorectal cancer[3].

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Individuals with blood groups other than O have a higher risk of cardiovascular and cerebrovascular diseases due to increased levels of plasma cholesterol and von Willebrand factor, which causes endothelial dysfunction and inflammation and increases their risk and severity[4–6]. Moreover, studies have demonstrated that individuals with group A are associated with a greater risk of 2019 novel Coronavirus infection compared to those with group O[7–8]. Individuals with group AB are more susceptible to human immunodeficiency virus (HIV) infection[9], while those with group B have a reduced likelihood of hepatitis B virus (HBV) infection[10]. These studies reveal a potential connection between ABO blood group and various diseases.

Blood transfusion is a commonly utilized treatment method in medical practice. Current blood transfusion therapy follows the basic principles of both homologous blood transfusion and component blood transfusion. This is to maximize the treatment effect and avoid adverse reactions to blood transfusion[11]. Blood transfusion therapy corrects anemia, rescues shock, treats infection, and improves coagulation dysfunction[11]. The transfusion requirements vary significantly among patients with different underlying pathologies, necessitating disease-specific therapeutic approaches. For example, patients with liver disease need to supplement FP or cryoprecipitate to ensure coagulation function due to coagulation factor synthesis disorders. The malignant tumor patients are more likely to suffer from anemia, which can be corrected by red blood cell (RBC) transfusion[12]. In addition, the distribution of ABO blood groups in a specific region and the susceptibility of people with different blood groups to certain diseases may influence the utilization of blood components[13].

The above studies revealed the correlation between ABO blood group and diseases. They emphasized the association between ABO blood group, diseases, and blood components utilization. Therefore, this study aims to investigate the correlation between ABO blood group, blood components, and various diseases. The findings of this study are expected to provide a scientific basis for clinical blood preparation and contribute to the development of more comprehensive transfusion strategies, ultimately improving therapeutic efficacy and patient satisfaction in transfusion medicine.

SUBJECTS AND METHODS

Research subjects

This study retrospectively collected information of inpatients who underwent ABO blood group testing at the Third Xiangya Hospital of Central South University from January 1, 2021 to December 31, 2023. General information was collected, including gender, blood group, clinical diagnosis, and admitting departments. Meanwhile, the inpatients treated with blood transfusion were sorted and screened. Patient details and blood transfusion data such as the type and amount of blood component administered were collected.

Inclusion and exclusion criteria

The inclusion and exclusion criteria are shown as below (***Fig. 1***).

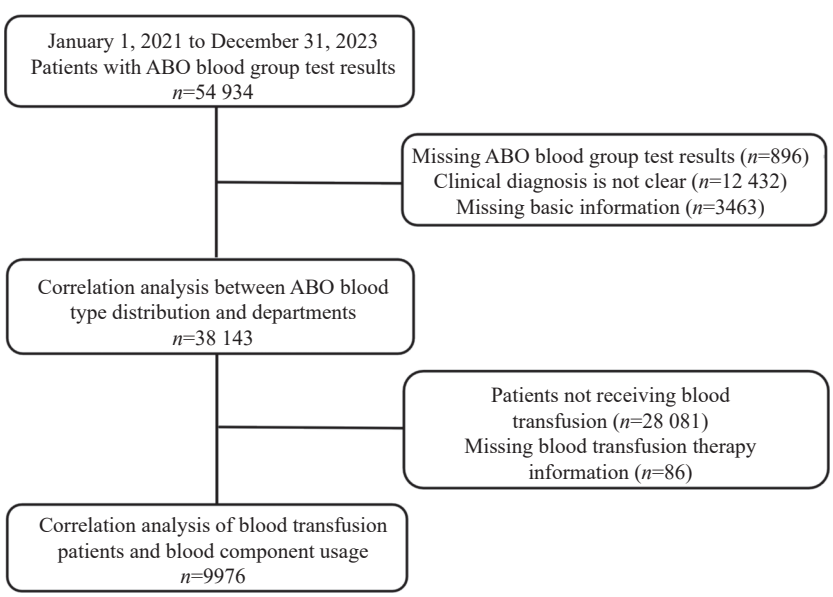

Fig. 1 **Flow chart of inclusion and exclusion of study subjects.**

Instruments and reagents

Instruments: Cassette centrifuge (Bioxun Biotech Co., Ltd., Changchun, China), TDL80-2B centrifuge (Anting Scientific Instrument Factory, Shanghai, China), 37U constant temperature water bath (Yiheng Technology Co., Ltd., Shanghai, China), KA-2200 blood typing centrifuge (KUBOTA, Fujioka, Japan).

Reagents: anti-A, anti-B, anti-A,B, and anti-A1 antibodies (Jiangsu ZoJiWat Bio-Pharmaceutical Co., Ltd., Jiangsu, China), anti-B, anti-A standard serum (Shanghai Blood Center, Shanghai, China), blood typing reagent card (Bioxun Biotech Co., Ltd., Changchun, China), anti-H antibody (Sanquin, Amsterdam, Netherlands), ABO reverse typing standard red blood cells (Shanghai Blood Biopharmaceutical, Co., Ltd., Shanghai, China).

ABO blood typing

Microcolumn gel was used for conducting positive and negative ABO blood typing. In cases of discordant results between positive and negative typing, confirmation testing was conducted using the test tube method. For samples demonstrating weak antigen expression, anti-H, anti-A,B or anti-A1 reagents were used to perform positive typing. The relevant test operations were strictly referred to the corresponding reagent instructions.

Statistical analysis

The data were analyzed using SPSS 27.0 software. The measurement data were described by mean ± standard deviation, while frequency and percentage were used to describe the count data. The chi-square test was employed to analyze the statistical differences between groups. A significance level of $P<0.05$ was considered statistically significant.

RESULTS

Correlation analysis between blood group distribution and departments

The study comprised 38 143 patients, with 12 492 males (32.75%) and 25 651 females (67.25%), and there was no variation in ABO blood group distribution between the two groups (***Table 1***). The overall ABO blood group distribution among the included patients demonstrated the following prevalence pattern : O (34.90%) > A (34.49%) > B (22.42%) > AB (8.19%) (***Table 1***).

This study encompassed data from 34 departments. Departments with limited sample sizes, including cardiology, radiological intervention, burns, endocrinology, traditional Chinese medicine, geriatrics, general medicine, plastic surgery, stomatology, breast and thyroid surgery, pain ward, and dermatology, were consolidated into an "other departments" category. Among the 34 clinical departments, four departments emerged as major contributors to the study population: gynecology (9461 cases, 24.80%), obstetric (7520 cases, 19.72%), urology (2103 cases, 5.51%), and hepatopancreato-biliary surgery (2025 cases, 5.31%) (***Table 2***). Chi-square tests were conducted to analyze ABO blood group distribution across different departments. The results showed a significant difference in ABO blood group distribution among patients in each department, with a χ^2 value of 86.696 and a significance level of $P<0.05$ (***Table 2***). Patients with group A accounted for a larger percentage in gynecology (34.53%), hepatopancreatobiliary surgery (35.60%), general surgery (35.00%), cardiothoracic surgery (34.85%) and gastrointestinal surgery (35.77%), while patients with group O exhibited increased representation in obstetric (34.97%), urology (34.53%), orthopedics (36.54%), gastroenterology (37.00%) and neuro-surgery (36.55%) (***Table 2***).

Correlation analysis between transfused patients and blood component usage

This study collected clinical blood use data from 9976 transfused patients, including 5191 males (52.03%) and 4785 females (47.97%). There was no significant difference in ABO blood group distribution between the two groups (***Table 3***). The ABO blood group distribution characteristics of transfused patients were O (36.02%) > A (34.31%) > B (21.59%) > AB (8.08%) (***Table 3***).

The diseases were categorized using statistical methods, and data from 22 diseases were summarized.

Table 1 **Blood group distribution of patients from 2021 to 2023**

Category	Gender	Blood groups				Total	χ^2	*P*
		A	B	O	AB			
Patients	Male	4324	2760	4415	993	12 492	3.254	0.345
	Female	8833	5790	8898	2130	25 651		
Total		13 157	8550	13 313	3123	38 143		

Table 2 **Blood group distribution of patients in different departments from 2021 to 2023**

Departments	Blood groups				Total	χ^2	*P*
	A	B	O	AB			
Gynecology	3267	2164	3243	787	9461		
Obstetric	2532	1704	2630	654	7520		
Urology	732	442	781	148	2103		
Hepatopancreatobiliary surgery	721	469	656	179	2025		
General surgery	697	442	678	174	1991		
Orthopedics	596	404	658	143	1801		
Cardiothoracic surgery	606	399	578	156	1739		
Gastroenterology	594	351	626	121	1692		
Gastrointestinal surgery	529	309	517	124	1479		
Neurosurgery	399	238	421	94	1152		
Hematology	307	194	346	65	912		
Nephrology	259	168	280	58	765	86.696	<0.05
ICU	229	173	242	52	696		
Pediatrics	202	147	194	58	601		
Otolaryngology	195	121	214	39	569		
Transplantation	207	119	183	32	541		
Infectious diseases	180	106	191	44	521		
Emergency department	116	101	144	37	398		
Oncology	102	66	105	18	291		
Neurology	87	52	102	14	255		
Ophthalmology	87	65	77	19	248		
Respiratory and critical care medicine	90	42	58	18	208		
Others	423	274	389	89	1175		
Total	13 157	8550	13 313	3123	38 143		

Table 3 **Blood group distribution of transfused patients from 2021 to 2023**

Category	Gender	Blood groups				Total	χ^2	*P*
		A	B	O	AB			
Patients	Male	1789	1109	1876	417	5191	0.407	0.939
	Female	1634	1045	1717	389	4785		
Total		3423	2154	3593	806	9976		

The data consisted of malignant tumors, uterine and bilateral accessory lesions, gastrointestinal bleeding, liver diseases, and kidney diseases. The patients' blood components were classified and counted in ***Table 4***. The transfusion data revealed that RBCs were the most frequently administered component, utilized in 8454 cases, followed by frozen plasma (FP) in 5099 cases, platelets (PLTs) in 1991 cases, and cryoprecipitate in 1523 cases. Blood component usage in each disease group was analyzed using the chi-square test, with a χ^2 value of 2974.703 and a significance level of $P<0.001$, and there were significant differences in blood component usage in patients with different diseases (***Table 4***). Patients with malignant tumors represented the largest proportion of RBC transfusion recipients (12.76%); patients with liver diseases accounted for the highest utilization rates of FP and cryoprecipitate (19.71% and 27.05%, respectively); patients with autoimmune hemolytic anemia were the most common recipients of PLT transfusion (30.29%) (***Table 4***).

Correlation analysis between blood group and blood component usage

From 2021 to 2023, the hospital administered 58 555.2 units of RBCs, 84 775.5 units of FP, 12 609.5 therapeutic doses of PLTs, and 30 944.5 units of cryoprecipitate (***Table 5***). In RBC transfusion, group A (34.56%) and group O (34.72%) patients accounted for the highest usage, with group AB patients having the lowest usage (8.73%); in FP transfusion, the highest usage was seem in group O patients (36.17%), while group AB patients had the lowest (7.51%); group O patients had the highest percentage of PLT transfusion (36.84%), while group AB patients had the lowest (6.95%); and when it comes to cryoprecipitate, group A patients accounted for the highest usage (34.21%), with the lowest seen in group AB patients (9.88%) (***Table 5***). Taking 1 unit (U) or 1 therapeutic dose as a standardized frequency unit, a

Table 4 **The use of blood components for transfused patients from 2021 to 2023**

Diseases	Blood components				Total	χ^2	*P*
	RBCs	FP	PLTs	Cryoprecipitate			
Malignant tumors	1079	612	190	134	2015	2974.703	<0.001
Uterine and bilateral accessory lesions	944	158	27	19	1148		
Gastrointestinal bleeding	861	528	72	160	1621		
Liver diseases	848	1005	243	412	2508		
Kidney diseases	818	444	71	60	1393		
Autoimmune hemolytic anemia	630	279	603	171	1683		
Trauma	427	289	55	89	860		
Orthopedic diseases	408	182	18	21	629		
Nervous system diseases	377	286	46	58	767		
Cardiovascular diseases	304	223	43	86	656		
Infectious diseases	304	259	139	87	789		
Respiratory diseases	217	131	51	46	445		
Pregnancy diseases	166	51	15	9	241		
Postoperative status	146	99	26	25	296		
Premature infants	137	109	24	22	292		
Other anemias	132	25	19	5	181		
Diabetes mellitus	122	42	12	10	186		
Other Hematological disease	95	55	132	30	312		
Myeloma	61	20	51	12	144		
Aplastic anemia	60	23	59	12	154		
Burns	54	77	15	4	150		
Other diseases	264	202	80	51	597		
Total	8454	5099	1991	1523	17 067		

RBCs: red blood cells; FP: frozen plasma; PLTs: platelets.

Table 5 **The distribution of blood component usage for transfusion patients from 2021 to 2023**

Blood groups	Blood components				Total	χ^2	*P*
	RBCs	FP	PLTs	Cryoprecipitate			
A	20 237	28 279	4430	10 587	63 533	374.746	<0.001
B	12 875	19 466	2658	7330	42 329		
O	20 330	30 661	4645	9972	65 608		
AB	5114	6371	877	3056	15 418		
Total	58 556	84 777	12 610	30 945	186 888		

RBCs: red blood cells; FP: frozen plasma; PLTs: platelets.

chi-square test was performed based on the frequency (usage) of each blood component across various blood groups. The results indicated that there was a significant difference in ABO blood group distribution among various blood component usages, as evidenced by a χ^2 value of 374.746 and P<001. The ABO blood group distribution was subsequently compared between the components, and the differences were statistically significant (P<0.05) (***Table 6***).

DISCUSSION

Research has demonstrated that individuals from diverse geographical locations and genetic backgrounds exhibit varying distributions of ABO blood groups. Individuals with different ABO blood groups may be more susceptible to various diseases[2,14]. At the molecular level, the relationship between ABO blood group and diseases is primarily related to the structure of blood group antigens and gene inheritance, as well as their potential association with pathogenesis[14–15]. In addition, the interplay between blood group antigens and diseases may be significantly influenced by the immune system's recognition and response. For instance, certain pathogens may be more likely to infect individuals with a particular blood group, while those with that blood group may exhibit increased resistance to certain diseases[16–17]. Differences in the immune system's recognition and response to various pathogens may be influenced by different blood group cell surface antigens[16–17]. Blood group antigens may

Table 6 **Comparison of ABO blood group distribution between different blood component usage**

Blood components	Blood groups				χ^2	*P*
	A	B	O	AB		
RBCs-FP	20 237	12 875	20 330	5114	113.953	<0.001
	28 279	19 466	30 661	6371		
RBCs-PLTs	20 237	12 875	20 330	5114	57.147	<0.001
	4430	2658	4645	877		
RBCs-Cryoprecipitate	20 237	12 875	20 330	5114	92.742	<0.001
	10 587	7330	9972	3056		
FP-PLTs	28 279	19 466	30 661	6371	33.401	<0.001
	4430	2658	4645	877		
FP-Cryoprecipitate	28 279	19 466	30 661	6371	265.482	<0.001
	10 587	7330	9972	3056		
Cryoprecipitate-PLTs	10 587	7330	9972	3056	170.178	<0.001
	4430	2658	4645	877		

RBCs: red blood cells; FP: frozen plasma; PLTs: platelets.

also interact with other factors in the body, affecting the onset and progression of diseases. However, more research is needed to fully understand the molecular mechanisms of the relationship between ABO blood group and diseases, as the current studies are not comprehensive enough to determine the specific mechanism of action and causal relationships involved. While exploring the connection between ABO blood group and diseases, it is significant to take into account individual differences and sample size issues. Genetic and physiological differences may cause the impact of blood groups on individual diseases to vary among people.

This study revealed that a large proportion of patients enrolled were from the department of gynecology and obstetrics, followed by those from urology, hepatopancreatobiliary surgery, general surgery, and other departments. These patients are more likely to present with transfusion indications such as blood loss and coagulation factor deficiencies. In clinical practice, the demand for blood products and the efficacy of transfusion therapy vary depending on different diseases. RBC transfusion represents a fundamental therapeutic intervention in clinical practice, primarily used for the treatment of anemia and blood loss. It is commonly utilized in patients with cancers, chronic anemia, and blood diseases[18–19]. PLT transfusion is primarily used to treat various platelet-related diseases, including primary thrombocytopenia and platelet dysfunction, as well as secondary thrombocytopenia caused by diseases[20]. FP transfusion can supplement coagulation factors, albumin, and other plasma proteins, which are essential for patients with impaired liver function[21]. Furthermore, FP is also indicated for diseases with abnormal coagulation function, effectively restoring normal coagulation function and controlling bleeding symptoms[22–23]. Cryoprecipitate is employed to treat various diseases related to coagulation function, including congenital coagulation factor deficiencies and hypofibrinogenemia[22–23].

The patients received different blood components based on their specific medical conditions in this study. It was closely related to the disease's pathogenesis and clinical symptoms. Malignant tumors are long-term diseases. Prolonged tumor invasion, radiotherapy, and chemotherapy may result in bone marrow suppression or alterations in iron levels in the body. Patients frequently develop cancer-related anemia and require multiple RBC transfusions to correct anemia[24–25]. This study demonstrated that patients with malignant tumors accounted for the predominant population receiving RBC transfusions, while liver diseases represented the largest cohort requiring FP and cryoprecipitate. This distribution pattern may reflect the characteristic clinical manifestations of liver diseases, such as jaundice, ascites, metabolic disorders, and coagulation dysfunction due to liver cell damage. FP and cryoprecipitate transfusions can supplement proteins and coagulation factors, maintain normal plasma osmotic pressure, and enhance coagulation function[26–27]. Autoimmune hemolytic anemia was the most common condition among patients receiving PLT transfusions. These patients experience high levels of RBC destruction in their bodies, leading to anemia symptoms and necessitating RBC supplementation, so these patients also received numerous RBC transfusions. In addition, individuals with autoimmune hemolytic anemia may experience thrombocytopenia symptoms, potentially resulting in bleeding. PLT transfusions can prevent major

bleeding[28]. The amount of blood components utilized is determined by patient's specific conditions, with some patients often requiring multiple blood products simultaneously. The amount of each blood component transfused varies depending on the disease severity. In addition, there is a correlation between the distribution of ABO blood groups in the population and the use of component blood. This study found that blood components from groups O and A were more commonly used, while those from group AB showed the lowest consumption rate. This pattern directly correlates with the distribution of ABO blood groups in the population, which demonstrated an approximate ratio of O : A : B : AB = 3: 3: 2: 1. There were more people with groups O and A, and fewer people with group AB. The utilization of blood components is influenced by multiple factors, including the prevalence of diseases in the region, the proportion of blood donors in the population, blood group distribution, blood storage and utilization practices, as well as the management measures employed by blood banks and blood transfusion departments during periods of blood supply constraints. This study has several limitations regarding the comparison of differences in blood component use for patients with different diseases. The variations in blood components usage within specific disease categories have not been refined and compared. For the time being, only the differences under a certain broad category of diseases have been discussed in a rough sense, indicating that further analysis and discussion will be necessary in the future.

Based on the relationship between blood component requirements and diseases, as well as the potential connection between ABO blood group and different diseases, this study explored the correlation between blood group and component use, providing valuable insights for clinical blood preparation and use, and formulating scientific, safe, and personalized transfusion strategies. Patients in departments like gynecology, obstetrics, urology, hepatobiliary-pancreatic surgery, and general surgery have a higher demand for transfusion therapy. This increased demand is primarily attributable to various conditions such as postpartum hemorrhage, ectopic pregnancy, primary liver diseases, surgical bleeding, or traumatic blood loss. Among these departments, patients with group A were most prevalent in gynecology, hepatobiliary-pancreatic surgery, and general surgery, while patients with group O were most common in obstetrics and urology. The high proportion of blood types A and O in departments with significant transfusion requirements aligns with the ABO blood group distribution observed in the study population. Additionally, this study revealed a correlation between blood types, diseases, and blood component usage. Among patients receiving red blood cell transfusions, those with malignant tumors accounted for the largest proportion, with a particularly high utilization rate of group A RBCs. This finding may be attributed to the fact that patients with malignant tumors are prone to cancer-related anemia, coupled with the elevated incidence of cancer among individuals with type A blood, thereby leading to the observed patterns. Nevertheless, the complex relationship between blood types, blood components, and diseases still warrant extensive investigation. Future research should employ large-scale samples, genomics, and proteomics to delve deeper into these connections, potentially offering new insights and approaches for disease treatment and transfusion therapy.

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Author contributions

Study Design, Guocai Li, Rong Gui, and Fengxia Liu; Data Collection & Analysis, Xueyuan Huang, Lin Qu, and Xionghui Zhou; Study Project Supervision & Management, Rong Gui and Fengxia Liu; Writing – Original Draft Preparation, Guocai Li; Writing – Review & Editing, Fengxia Liu.

Ethics statement

Not applicable.

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

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Declaration of competing interest

The authors declared no conflict of interests.

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