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BLOOD TYPE AND ITS ROLE IN DISEASE DEVELOPMENT

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ABSTRACT

Blood type is a crucial biological marker with significant implications in medicine, genetics, and anthropology. This article explores the fundamentals of the blood group system, key historical discoveries, its relevance in clinical practice, and its influence on health and disease susceptibility.

Keywords: Blood type, ABO system, Rhesus factor, erythrocytes, COVID-19, cardiovascular pathologies, thromboembolic complications, oncological diseases.

INTRODUCTION

In recent years, numerous studies have explored the link between blood types and susceptibility to various diseases, including cardiovascular conditions, thromboembolic complications, and cancer. The connection between blood groups and COVID-19 has also gained significance following the coronavirus pandemic. This review focuses on analyzing current scientific data on the impact of blood type on human health.

The concept of blood groups was first introduced in 1901 by Austrian physician Karl Landsteiner. He discovered that mixing blood from different individuals could cause clumping, leading to the identification of the ABO blood group system. Further research expanded on this phenomenon, paving the way for modern blood transfusion techniques. In 1940, Landsteiner and Alexander Wiener made another significant breakthrough in hematology and transfusiology by discovering the Rh factor, which helped prevent serious complications in blood transfusions [4].

Currently, multiple blood group systems are recognized, but the most important are the ABO system and the Rh factor. The ABO system classifies blood into four groups—A, B, AB, and O—based on the presence of specific antigens (A and B) on the surface of red blood cells. Individuals with blood type O lack both A and B antigens on their erythrocyte membranes [2]. Erythrocytes contain A and B agglutinogens, while plasma contains α and ß agglutinins. A person cannot simultaneously have both A agglutinogen and α agglutinin or B agglutinogen and ß agglutinin, as this would trigger agglutination, leading to severe reactions, including fatal outcomes. Incompatibility in blood transfusions, based on the ABO system and Rh factor, can result in erythrocyte agglutination and hemolysis [7].

The Rhesus factor (Rh) is a key antigen that determines whether a person has Rh-positive (Rh+) or Rh-negative (Rh-) blood, making it a crucial factor in transfusions [14].
Additionally, other blood group systems, such as Duffy, Kell, and Kidd, are less common but play a significant role in blood transfusion compatibility, organ transplantation, and immune responses [13].

Clinical significance. Blood type and Rh factor are crucial in medicine, particularly in ensuring compatibility during blood transfusions. In cases of incompatibility, red blood cells can clump together, forming large aggregates that lead to hemolysis, blockages in small blood vessels, and potentially fatal consequences [11].
Blood types are genetically inherited, following dominant-recessive patterns: A and B are dominant, while O is recessive. This genetic understanding is widely applied in forensic medicine for determining paternity and familial relationships. Additionally, research suggests that blood types may be linked to specific characteristics of the immune system [15].
Some studies suggest that blood type may influence susceptibility to certain diseases. For instance, individuals with blood type O lack A and B antigens on their red blood cells, making them less prone to thrombosis and, consequently, at a lower risk of cardiovascular diseases compared to those with blood types A or B. People with blood type A tend to have higher blood pressure, total cholesterol, and LDL cholesterol than those with blood type B. However, this group faces the greatest risk of cardiovascular disease, as they experience rapid development of left ventricular hypertrophy [9].
Individuals with blood type A show heightened sensitivity to the SARS-CoV-2 virus. This suggests that susceptibility to coronavirus infection may be influenced by blood type, though this factor accounts for less than 50% of cases [5, 10]. Blood type A has also been linked to a higher risk of thrombosis and certain stomach cancers. Those with blood type B may be more vulnerable to specific infections, including the Epstein-Barr virus. Meanwhile, individuals with blood type AB have an increased likelihood of developing cognitive disorders and dementia in later life [1].
Blood type influences the risk of infections, the development of chronic diseases such as diabetes, asthma, and cancer, as well as the composition of gut bacteria. Since bacteria and viruses can recognize or mimic blood antigens, they impact the immune system's response [3].
Additionally, blood types A, B, and AB are associated with a higher risk of thrombosis when using peripheral catheters, whereas blood type O lowers this risk, particularly among Asians [17].
Furthermore, individuals with blood type O have been found to have a higher risk of developing lung adenocarcinoma compared to those with blood type A [16].
However, research indicates that genetics, along with various external and internal factors—such as heredity, gender, age, stress, chronic conditions, diet, and harmful habits like smoking and alcohol consumption—collectively influence overall health and the likelihood of developing these diseases [12].
Scientists are increasingly finding evidence linking blood chemistry, including blood groups and antigenic structures, to the risk of various diseases. One of the promising areas of research is the study of the influence of blood type on the human microbiome and metabolism. The

antigens of the ABO system, which are glycoproteins, are broken down by intestinal microorganisms. A recent Finnish study revealed a statistically significant relationship between blood type and microbiome composition: carriers of antigen B (groups B and AB) had a different bacterial profile. The ability to release blood group antigens into biological fluids can alter the microbial community and affect human health. Since the blood type is determined by oligosaccharide structures, it can be assumed that the biochemical characteristics of a person depend on the blood type, antigens and secretory status. Metabolic studies have already revealed biochemical differences related to ethnicity, and have also shown that the distribution of blood groups varies among different ethnic groups. A study by Sumner and his colleagues from the NIH CommonFund Eastern Regional Center for Metabolomics confirmed that people's metabolic profiles vary depending on their blood type. [6]

It is believed that the diversity of blood groups arose as a result of the evolutionary struggle and adaptation between microorganisms and mammals. Although the mechanisms of these interactions have been well studied using cultured bacterial strains, their effect on human symbiotic bacteria has not been sufficiently studied. Further research will help to better understand the role of the microbiome in maintaining health and developing diseases. Studies that did not reveal a link between blood type and the microbiome were based on large samples, which increases the reliability, but increases the influence of uncontrolled factors. At the same time, the analysis of small, homogeneous groups, such as a cohort of 64 healthy Finns with a non-Vegetarian diet, reduces the impact of hidden variables. The key factor in the discrepancies in the results is probably nutrition. Diet significantly affects the microbiome, and differences in diet can mask subtle effects related to blood type. Experiments on mice have shown that with a diet low in plant polysaccharides, carbohydrates affect the composition of the microflora, but this effect disappears with a diet rich in fiber. Most studies have been conducted among healthy adults, but the effect of blood type on the microbiome may be more pronounced in dysbiosis and diseases, which underscores the need for further research. [3]

This study presents a generalized SIR model that takes into account the effect of blood group antigenicity on infection rules. The analytical solution for the exponential phase of infection spread made it possible to theoretically test the previously proposed hypothesis. The model has been tested on local data, taking into account the distribution of infected COVID-19 by blood type and globally through the analysis of incidence curves in different countries. The findings confirm the correspondence of the hypothesis about the influence of blood type on the prevalence of COVID-19 to epidemiological data. Although accurate validation requires an analysis of the interaction of antigens with SARS-CoV-2, the main focus of the work is on its mathematical justification. The proposed formalism also reveals a link between the regional rates of infection and the distribution of blood groups. It is noted that geographical heterogeneity may depend on other population-specific antigens. [8]

CONCLUSION

The study of blood groups continues to be an urgent topic in science and medicine. Their role in transfusions, transplantation, genetics, and disease predisposition makes this area important for further research. Depending on blood groups, there is a predisposition to various diseases, but not only genes are important, but also lifestyle, nutrition, bad habits, stress, as

they are a key link in the development of diseases. Understanding these aspects allows us to develop new methods of treatment and diagnosis, which makes the contribution of this topic to medicine invaluable. In the future, new technologies may appear that will make it possible to even more accurately take into account the individual characteristics of blood in the treatment of various diseases.

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