The association between ABO blood group and human disease

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Abstract

Antigens in the ABO blood group system, besides being expressed on the surface of red blood cells, it is also expressed on other cell surfaces such as white blood cells, gastrointestinal epithelium cells, and platelets. From previous studies, it has been found that the expression on these cell surfaces affects various diseases, including infectious diseases and chronic non-communicable diseases (NCDs) as well, resulting in the rate of various diseases in each blood type being unequal. From searching and collecting many research papers from various databases, it was found that people with blood type A and blood type O have a greater risk of infection with the SAR-CoV2 that causes COVID-19 than people with other blood types, while in chronic non-communicable diseases it was found that people with the O blood type have a greater a risk of developing diseases such as high blood pressure coronary heart disease less than people with other blood types. There are also studies that have found that the ABO blood type affects the behavior of food choices. This may be another reason for the occurrence of various diseases as well. In this research article has also studied role of ABO antigen expression in various disease mechanisms.

Keywords; blood; blood type; disease

Background

Antigens in the ABO blood group system, which consist of Antigen H, A, and B, were discovered many centuries ago. These antigens are composed of complex carbohydrates. Despite having similar core structures, Antigen A and Antigen B differ due to the expression of the A and B genes. This results in the addition of N-Acetyl glucosamine and Galactose, forming Antigen A and Antigen B, respectively. However, in individuals who do not express these genes, there is no additional sugar group added, resulting in Antigen H. As shown in Figure 1, the expression of these antigens on the surface of red blood cells is significant for the ABO blood group system, affecting blood donation and transfusion (Ewald, Sumner, 2016). The expression of these antigens varies across different ethnicities and countries. In Thailand, for instance, the majority of the population has blood type O (40.8%), followed by blood type B (36.8%) and blood type A (16.9%), with AB being the least common (4.97%) (Nathalang, Kuvanont, Punyaprasiddhi, Tasaniyanonda, Sriphaisal, 2001). Similarly, in China, blood type O is prevalent (48.0%), followed by blood type A (28.0%), and then blood type B (19.0%), with AB being the least common (5.6%) (Sun, Wang, Niu, Ma, Xing, Song et al, 2022).

In India, however, blood type B is more common (32.0%), followed by blood type O (28.0%), blood type A (25.8%), and AB being the least common (14.7%) (Agarwal, Thapliyal, Chatterjee, 2013). These variations in blood type distribution are also observed across Europe, where countries like France have a similar prevalence of blood types O (36.5%) and A (38.2%), followed by blood type B (7.7%) and AB (2.5%) (Borghese, Chartier, Souza, Santulli, Lafay-Pillet, de Ziegler et al, 2014).

In Hungary, blood type A is the most common (33%), followed by blood type O (27%), blood type B (16%), and AB (8%). Similarly, Norway has a high prevalence of blood type O (41.6%), followed by blood type A (33.2%), blood type B (6.8%), and AB (3.4%). In Africa, blood type distribution varies, with a predominance of blood type O, followed by blood type A, in countries like Nigeria (Erhabor, Adias, Jeremiah, Hart, 2010).

These variations in the expression of the A and B genes are evident globally, even in neighboring regions. While neighboring countries may share borders, their blood type distributions can differ significantly. These differences in blood type distribution have led to speculation that the ABO antigen expression might have implications for various diseases. Scientists worldwide have studied the relationship between ABO antigen expression and the occurrence of diseases in different populations. Therefore, this academic article compiles the results of studies exploring the connection between ABO blood group antigens and various diseases across diverse population groups worldwide.

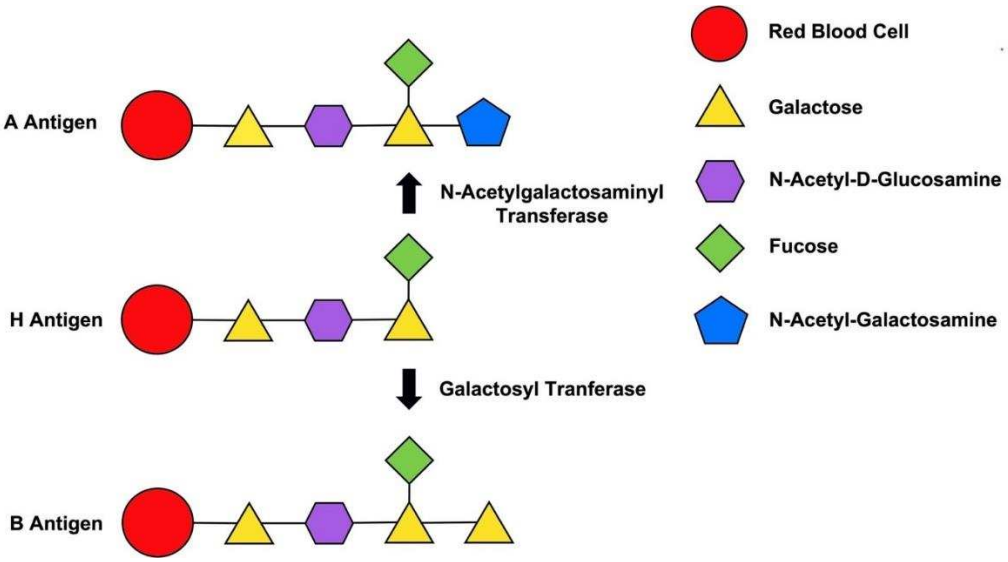

Figure 1 illustrates the structural characteristics of ABO blood type antigens.

In addition to being expressed on the surface of red blood cells, ABO blood type antigens are also found to be expressed on other cell surfaces, such as platelets, white blood cells, and certain types of tissues. Furthermore, these blood group antigens can also be detected in bodily secretions like milk, mucus, and urine. The expression of ABO antigens on these cell surfaces plays a significant role in the susceptibility to various diseases, including infectious diseases, cancer, and non-communicable diseases (NCDs), in individuals with different ABO blood types (Abegaz, 2021).

The expression of ABO antigens and its association with infection diseases:

Infectious diseases arise when pathogenic microorganisms enter the body and the immune system is unable to eliminate them effectively, leading to the development of various pathologies. Pathogens causing infectious diseases can include bacteria, viruses, or parasites. When these pathogens enter the body, they trigger immune responses from both innate immunity and adaptive immunity systems, allowing the body to eliminate them. However, if the body is unable to completely eliminate the pathogens, it results in the occurrence of various diseases. Studies have shown that A, B, and H antigens expressed on various cell surfaces function as receptors

for pathogens, facilitating their entry into cells. Additionally, both Anti-A and Anti-B antibodies also play a role in disease resistance (Abegaz, 2021).

Gastritis is a condition characterized by sores in the stomach or the initial part of the small intestine. Currently, it's understood that one of the causes of gastritis is the infection by Helicobacter pylori bacteria. This bacterium can thrive and grow even in acidic conditions within the stomach. Infection with H. pylori leads to inflammation and ulcers in the stomach. H. pylori attaches to the ABO antigens expressed on cell surfaces to enter the cells. Consequently, individuals with blood type O are more susceptible to H. pylori infection compared to those with other blood types. H. pylori infection is a crucial factor in the future development of stomach cancer, as it causes cell death in the stomach lining, resulting in ulcers and ongoing inflammation, which can lead to more severe disease development (Diaz, Valenzuela Valderrama, Bravo, Quest, 2018).

Norovirus infection is another abrupt cause of acute gastritis. It's found that around 20% of acute gastritis cases are caused by norovirus infection. Norovirus infection is prevalent in children and contributes to the deaths of over 200,000 children worldwide. Norovirus is highly contagious and even a small amount of the virus can cause infection. Therefore, controlling this virus's spread is challenging. The severity of illness varies among individuals infected with the norovirus. Genetic studies have shown that the expression of ABO antigens in blood type ABO influences norovirus infection and disease severity. People with blood type O are at a higher risk of norovirus infection compared to individuals with other blood types. Notably, norovirus has the highest binding ability to A antigens, followed by B antigens, with the least binding to O antigens. When norovirus attaches to the ABO antigens on the cell surfaces, it enters the cells, causing infection and subsequent symptoms such as diarrhea and vomiting. In severe cases, it can even lead to death. In summary, the population with blood type O has the highest susceptibility to norovirus infection, followed by blood types A, AB, and B having the lowest susceptibility (Nordgren, Svensson, 2019).

Malaria, also known as "shaking fever" or "malaria," is caused by an infection with the protozoan parasite Plasmodium, commonly referred to as the malaria parasite. There are four types of Plasmodium species that cause disease in humans: Plasmodium falciparum, which is the primary cause of severe cases of malaria; Plasmodium vivax, a less severe form; Plasmodium malariae; and Plasmodium ovale. When infected with malaria, the parasites develop in the liver and red blood cells, leading to symptoms characteristic of the disease. Studies have found a relationship between blood types and susceptibility to Plasmodium falciparum infection. Individuals with blood type O have a higher risk of infection, whereas those with other blood types have lower risks (Zerihun, Degarege, Erko, 2011; Cserti, Dzik, 2007). Furthermore, blood type O has been linked to the severity of malaria. Individuals with blood type O are less likely to develop large red blood cell clumps known as "rosettes," which can block blood vessels and cause organ damage. Although the rate of rosette formation is lower in blood type O individuals, those with blood type O who contract malaria can still experience smaller rosette formations (Afoakwah, Aubyn, Prah, Nwaefuna, Boampong, 2016).

COVID-19, caused by the novel coronavirus strain called SARS-CoV-2, emerged in December 2019 and quickly led to a global pandemic. The virus spreads from person to person through respiratory droplets released from the nose and mouth. Once the virus enters the body, it can cause respiratory illness. The severity of COVID-19 varies among individuals, with older adults, those with weakened immune systems, and those with underlying health conditions being more vulnerable to severe outcomes, including death. Research from various countries has indicated a connection between blood types and susceptibility to COVID-19. Individuals with blood types A and O are more likely to be infected with the virus compared to other blood types. This could be attributed to the ability of the Anti-A antibodies to bind to the S-protein of the virus, inhibiting its entry into cells. As a result, individuals with blood type B have a lower likelihood of COVID-19 infection. However, blood type has not been found to have a significant impact on the severity of COVID-19 (Kim, Latz, DeCarlo, Lee, Png, Kibrik et al., 2021).

The expression of ABO antigens in blood type AB and its association with the risk of non-communicable diseases (NCDs)

Non-communicable diseases are diseases that occur in each individual and cannot be transmitted from person to person. Examples of diseases in this category include cancer, diabetes, atherosclerosis, cardiovascular diseases, high blood cholesterol levels, and high blood pressure (hypertension). The non-communicable diseases have various contributing factors, such as improper diet, smoking, lack of physical activity, external factors like high pollution levels, or internal factors like variations in gene expression. Additionally, the blood type AB-O has been found to have an impact on the occurrence of non-communicable diseases.

Cardiovascular diseases, a subgroup of non-communicable diseases, refer to conditions where the red blood vessels supplying the heart muscle become constricted or lose their flexibility, leading to insufficient blood supply to the heart muscle. The primary cause often involves the accumulation of fats along the blood vessel walls, resulting in thicker vessel walls. These thicker walls can trigger the formation of blood clots (thrombus) that can lead to blockages in various blood vessels, potentially causing fatalities.

Research has shown that individuals with non-O blood groups, such as AB, B, and A, which are collectively referred to as Non-O, are at a higher risk of developing cardiovascular diseases compared to those with blood type O. Furthermore, the severity of cardiovascular diseases is also greater in the Non-O blood group. Studies conducted in Taiwan and South Africa, for instance, revealed that individuals with blood type AB have a significantly higher risk of acute myocardial infarction (heart attack) than individuals with other blood types.

Several factors contribute to this elevated risk and severity of cardiovascular diseases in the Non-O blood group. One such factor is high cholesterol levels in the blood, which can initiate injury to blood vessel walls. This can lead to the accumulation of cholesterol at the injured site, initiating the process of blood vessel hardening. It has been found that the impact of blood type AB on the risk of cardiovascular diseases related to high cholesterol levels is approximately 10% through elevated levels of cholesterol in the blood. Additionally, elevated levels of low-density lipoprotein (LDL) cholesterol, often referred to as "bad" cholesterol, are associated with the severity of cardiovascular diseases.

Research has also highlighted the increased risk of blood clot formation (thrombin) in the Non-O blood group. The expression of von-Willebrand Factor (VWF), a glycoprotein involved in platelet aggregation and blood clotting, is higher in the Non-O blood group compared to the O blood group. This leads to an increased risk of thrombotic occlusion in blood vessels among individuals in the Non-O group, with the risk being up to 2 times greater than those with blood type O.

Furthermore, blood type AB-O has been associated with specific dietary preferences. Research conducted in Greece found that individuals with blood type AB are more likely to consume diets high in cholesterol and have higher rates of smoking compared to other blood types. These factors may contribute to the increased risk of cardiovascular diseases in the Non-O blood group.

In conclusion, the blood type AB-O is linked to an elevated risk and severity of cardiovascular diseases, with factors such as high cholesterol levels, increased thrombin formation, and dietary preferences playing roles in this association. Understanding these connections can contribute to better preventive strategies and healthcare interventions for individuals with specific blood types.

Conclusion

It can be observed that the expression of antigens in the AB-O blood group has implications for the development of various diseases, whether infectious or non-communicable. Therefore, understanding the risk rates of different diseases for each blood type could be used as a guideline for managing the health of individuals with specific blood types, aiming to reduce the occurrence of various diseases or prevent the severe manifestation of diseases. However, the impact of the AB-O blood group on disease rates is relatively minor. Thus, maintaining robust health through exercise, boosting the immune system, consuming appropriate diets, receiving disease-preventive vaccinations, avoiding various pollutants, all contribute significantly to disease prevention.

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