REVIEW

Ozge Beyazcicek[1]
Ersin Beyazcicek[1]
Serif Demir[1]

[1] Department of Physiology, Medical School, Duzce University, Duzce, Turkey

Corresponding Author:
Ozge Beyazcicek
Department of Physiology, Medical School, Duzce University, Duzce, Turkey
mail: ozgebeyazcicek@gmail.com
Phone: +90 5532919194

Received: 14.12.2020
Acceptance: 25.02.2021
DOI: 10.18521/ktd.840276

Konuralp Medical Journal
e-ISSN1309–3878
konuralptipdergi@duzce.edu.tr
konuralptipdergisi@gmail.com
www.konuralptipdergi.duzce.edu.tr

Are Blood Groups Protective Against COVID-19?

ABSTRACT
The SARS-CoV-2 or COVID-19 disease, which has spread rapidly since its first appearance and caused pandemic, has become more dangerous day by day, and by infecting large masses caused the death of many people. The numbers of cases and deaths reaching dangerous levels globally have pushed scientists to get to know this infection more closely and to investigate preventive and therapeutic methods. At this point, scientists have discovered, based on past infectious disease researches, that some individuals are more susceptible to certain infections. Importantly, in the light of this information, it has been determined that there is a relationship between infectious diseases and blood groups, and individuals with certain blood groups are more susceptible to these infectious diseases. The obtained data suggested that there may be a relationship between blood groups and SARS-CoV-2, and research has been shifted in this direction in order to quickly determine susceptibility to the disease. Indeed, relationships between SARS-CoV-2 patients' blood groups, from hospitals in China, US, Italy, Spain and Turkey, and caught this infectious were investigated. It has been demonstrated that blood groups have an effect on getting this disease. With the discovery of this relationship, it has been revealed in studies that A, B, AB and O blood groups can be a potential biomarker in determining the sensitivity to COVID-19 infection. Studies have determined that individuals with blood type A have an increased sensitivity to COVID-19, and individuals with blood type O have a decreased sensitivity to it. It is thought that the reason for the decreased sensitivity to COVID-19 in individuals with that blood group, and the increased sensitivity seen in individuals with blood group A is due to the antibody A in the blood. This antibody can inhibit virus-cell adhesion in individuals with antibody A. Therefore, it is very important for individuals with blood group A, who do not carry this antibody in their blood, to use personal protective equipment to protect themselves from COVID-19. The purpose of this review is to bring together studies that reveal the relationship between COVID-19 and blood types.
Keywords: COVID-19, ABO Blood Groups, ACE2, S Protein.

Kan Grupları COVID-19'a Karşı Koruyucu Mu?

ÖZET
İlk ortaya çıktığı andan itibaren hızla yayılan ve pandemiye neden olan SARS-CoV-2 veya COVID-19 hastalığı, gün geçtikçe daha tehlikeli bir hale gelmiş ve geniş kitlelere bulaşarak birçok insanın ölümüne neden olmuştur. Küresel olarak tehlikeli seviyelere ulaşan vaka ve ölümlerin sayısı, bilim insanlarını bu enfeksiyonu daha yakından tanımaya ve önleyici ve tedavi edici yöntemleri araştırmaya itmiştir. Bu noktada bilim insanları, geçmiş enfeksiyöz hastalıkları araştırmalarına dayanarak bazı bireylerin bazı enfeksiyonlara daha duyarlı olduğunu keşfetmişlerdir. Önemli olarak, bu edinilen bilgiler ışığında geçtiğimiz yıllarda yapılan çalışmalarla enfeksiyöz hastalıklar ile kan grupları arasında bir ilişki olduğu saptanmış ve belirli kan gruplarına sahip bireylerin bu bulaşıcı hastalıklara daha duyarlı oldukları saptanmıştır. Elde edilen veriler kan grupları ile SARS-CoV-2 arasında bir ilişki olabileceğini düşündürmüş ve araştırmalar hastalığa karşı duyarlılığın hızlı bir şekilde belirlenmesi amacıyla bu yöne kaydırılmıştır. Nitekim Çin'in farklı bölgelerinde, Amerika Birleşik Devletleri'nde, İtalya, İspanya ve Türkiye'deki hastanelerde SARS-CoV-2 hastalarının kan grupları ile bu hastalığa yakalanma ilişkileri araştırılmış ve kan gruplarının bu hastalığa yakalanmada etkisinin olduğu ortaya konmuştur. Bu ilişkinin keşfedilmesiyle birlikte insanlarda bulunan A, B, AB ve O kan gruplarının COVID-19 enfeksiyonuna duyarlılığın belirlenmesinde potansiyel bir biyobelirteç olabileceği araştırmalarda ortaya çıkmıştır. Yapılan çalışmalarda kan grubu A olan bireylerin COVID-19'a karşı artmış bir duyarlılığının olduğu ve kan grubu O olan bireylerin ise azalmış bir duyarlılığa sahip olduğu belirlendi. O kan grubuna sahip bireylerde COVID-19'a karşı görülen azalmış duyarlılığın ve A kan grubuna sahip bireylerde görülen artmış duyarlılığın nedeninin kanda bulunan A antikorundan kaynaklandığı düşünülmektedir. A antikoruna sahip bireylerde bu antikor virus-hücre adezyonunu inhibe edebilmektedir. Bu nedenledir ki özellikle bu antikoru kanında taşımayan A kan grubuna sahip bireylerin COVID-19'dan korunması için kişisel koruyucu ekipman kullanmaları çok önemlidir. Bu derlemenin amacı COVID-19 ile kan grubu arasındaki ilişkiyi ortaya koyan çalışmaları bir araya getirmektir.
Anahtar Kelimeler: COVID-19, ABO Kan Grupları, ACE2, S Protein.

INTRODUCTION

SARS-CoV-2, which has been spreading around the world since December 2019 and declared as a pandemic by the World Health Organization (WHO), causes new type of coronavirus infection disease-2019 (COVID-19). Today, more than 200 countries worldwide have been affected by COVID-19, over 64.5 million people have been infected and approximately 1.500.000 patients have died from this virus (the number of cases and deaths were reported from https://coronavirus.jhu.edu/map.html, as of 03 December 2020). As of December 2020, for the number of COVID-19 cases Turkey is in the 18th place, and for the number of the death is in the 20th place between the world countries.

SARS-CoV-2 first passed from bat to people and continued to spread from person to person in the following period. As a matter of fact, the virus spread by the sneezing or coughing of the infected individual may hang in the air in droplets for a while, which means that the virus; by entering the system of a healthy individual through the eyes, mouth, respiratory tract or food, it leads to infection. The virus can then infect the induvidiuals very quickly.

Previous studies have revealed that blood group antigens are effective receptors for various infectious microorganisms (1). Specific ABO glycan antigen receptors that bind to the spike (S) proteins of the virus during infection can support the entry of the virus into the cell (2).

Generally SARS-CoV-2 can enter the human cells in two ways. In first and main way, viral spike glycoproteins attach to the receptors of the target cell (3). Target cell for SARS-CoV-2; while pulmonary cells, the target receptor is angiotensin converting enzyme-2 (ACE2), which is expressed in mucosal cells. Angiotensin converting enzyme-2 is an enzyme that converts angiotensin to 1-7 by hydrolyzing angiotensin II, causing blood pressure to drop. The COVID-19 virus binds to this receptor and enters the cell (3). In addition to ACE2, CD147 and TMPRSS2 are two of the membrane proteins used by the virus to enter the cell. CD147 is a heavily glycosylated type I transmembrane protein involved in spermatogenesis and fertilization, neural network formation and development, tumor metastasis and angiogenesis, and cardiovascular disease. On the other hand TMPRSS2, is a slightly glycolyzed membrane protein that plays important roles in human and mammal development and homeostasis, as well as in various diseases such as cancer and influenza infection(4). In the second way, viral entry is dependent on the antibody. These antibodies bind to the virus in one hand, and on the other hand binds to the Fcγ receptor. By this way virus can enter to the immunoglobulin cells which express the Fcγ receptor (3).

In general, virus-specific antibodies are considered antiviral and play an important role in various ways of controlling virus infections. In some cases, however, the presence of specific antibodies may be beneficial for the virus. This activity is known as antibody-dependent enhancement (ADE) of virus infection. The antibody-dependent enhancement of virus infection is a phenomenon in which virus-specific antibodies improve the entry of the virus into the cell, and in some cases the virus' proliferation in monocytes/macrophages and granulocytic cells by interacting with Fcγ and/or complement receptors (5).

Pulmonary macrophages are at the center of the inflammatory response in COVID-19 infection. As a result, beside the binding to ACE2, CD147 and TMPRSS2 membran proteins to enter mucosal cells, enter to the macrophages with the ADE is the second way.

With more than 68.3 millions people infected today and about 1.5 millions deaths, scientists have begun to investigate the pathology, diagnosis, treatment and individuals' susceptibility to COVID-19. Fever, cough and weakness are among the main symptoms of COVID-19 (2).

Clinical observations on cases have been shown that the age, male gender, chronic diseases such as cardiovascular disease, diabetes, chronic obstructive pulmonary disease (COPD) and hypertension, constitute increased disease severity beside with an increased risk of disease for COVID-19 infection (6). Today, there is not biomarker has been found yet to fully reveal the susceptibility to COVID-19 (7). However, studies have shown that A, B, AB and O blood groups can be a potential biomarker in determining the susceptibility to COVID-19 infection.

Blood groups were first described as A, B, AB and O by Karl Landsteiner, an Austrian immunologist in 1901. Landsteiner also identified as carbohydrate epitopes on erythrocytes. These carbohydrate epitopes are also called antigens, and blood groups differ from person to person depending on the type of these antigens and whether they are present on the surface of the erythrocyte. The trisaccharide parts, which are the antigenic determinants of blood group A and B, are GalNAcα1-3- (Fucα1,2) -Galβ- and Galα1-3- (Fucα1,2) -Galβ-, respectively, while the determinative disaccharide portion of O blood group is Fucα1,2-Galβ- (7). The genetic factor plays an important role in determining blood groups.

The ABO blood group system is a very stable genetic material found in the third region fourth band (9q34) on the long arm of the 9th chromosome, and is closely related to many diseases (8). Davidson et al. stated that the

expression of blood group antigens varies between human populations and geographic regions (9). The surface of the red blood cell has many surface antigens that can affect susceptibility to many diseases.

Researches attempting to reveal the relationship between blood groups and human health began in the early 1900s. As a result, blood groups are; it has been associated with the emergence of various diseases such as cardiovascular disorders, neurological disorders, cancer and infections (10). As a matter of fact, it has been reported in previous studies that individuals without O blood group are more susceptible to coronary diseases (11), and individuals with B blood group are more likely to have type 2 diabetes compared to other blood groups, and also the Rh factor has no effect on susceptibility (12).

Blood groups can determine the risk of developing the disease, affect the progression of the disease, as well as the severity and consequences of the symptoms shown (2). To determine this, a retrospective study was conducted by a group of Japanese scientists to analyze the effect of the ABO blood group on the disease in patients with severe trauma. As a result, higher mortality and less ventilator time have been reported in patients with O blood group. In addition (13), blood groups have been shown to be associated with chronic heart failure (14) and esophageal squamous cell carcinoma development and outcomes (15). However, other studies have provided contradictory evidence that blood groups are not a risk factor for various diseases (16).

In addition, previous researches have revealed that there is a relationship between ABO blood groups and many infectious diseases and the severity of these diseases. As an example of these diseases; SARS-CoV-1(17), *P. falciparum* (18), *H. pylori*(19), *Norwalk virus* (20), *hepatitis B virus* (21) can be given.

Studies examining the relationship between blood group and SARS-CoV-2 have gained great importance recently, and revealing this relationship has become the focus of many researchers. When the SARS virus first appeared in 2003, as the first of the studies on the association of blood groups with SARS virus can be given as Cheng et al.'s study that revealed a relationship between this virus and blood groups (17). According to the results obtained, individuals belonging to the blood group O showed less susceptibility to SARS virus compared to other blood groups (17). Moreover, natural mechanisms have been investigated, and it has been demonstrated that antibodies of the human anti-histo-blood groups block the interaction of the virus and the cell by binding to the S protein of the virus (22).

In order to reveal the association between SARS-CoV-2 and blood groups, the study done by Zhao et al.'s by is of great importance. In this study, blood groups data obtained from 2173 patients diagnosed with COVID-19 and blood groups data obtained from 27.080 healthy individuals for control purposes were compared in Wuhan and Shenzhen cities of China (7). As a result, the distribution of blood groups of healthy individuals collected from these two cities; It was found as 32.16% blood group A, 24.90% blood group B, 9.10% blood group AB, 33.84% blood group O (7). On the other hand, the blood group distribution of patients diagnosed with COVID-19 has determined as 37.75% blood group A, 26.42% blood group B, 10.03% blood group AB, 25.80% blood group O (7) As a result of this study, it was found that there is an association between COVID-19 and blood groups. Specifically, in this relationship, blood group A was associated with an increased risk of developing COVID-19, while blood group O was associated with a reduced risk. It has been demonstrated with this study that different blood groups can be a biomarker for differential susceptible for COVID-19 (7). In another study, which is similar to this study, the rates of infection of the hospital staff of blood group O and non-blood group O were compared, and it was reported that those with blood group O were infected with a lower risk (17). In this study also looked at the distribution of the blood group between sex and different age groups. Patients were divided into three different groups as under the age 40, between the age 41-59 and over the age 60. The distribution of blood groups showed similar rates in different age groups and in male and female patients. This situation revealed that the distribution of blood group does not depend on a certain gender or a certain age range (7).

Another study, similar to Zhao et al.'s study and supported it, was conducted by Zietz and Tatonetti, and the research was conducted in the New York Presbiterian (NYP) hospital (23). In this study, the relationship between the SARS-CoV-2 and infection status of individuals with ABO Rh+ blood group was investigated on 1559 individuals, 682 of whom were diagnosed with COVID-19 (23). In both cases, the result was significant only in Rh+, but blood group A was found higher and blood group O was found lower in patients diagnosed with COVID-19 which compare to the healthy individuals (23). As a result of the study, a negative relationship was found between O blood group and COVID-19. Indeed, in patients with SARS, O blood group has been identified as a rare blood group (17). In addition, no significant relationship was found between blood groups and mortality of cases (17). Similar studies support these findings with their studies(24-26).

Indeed, one another study performed by Zietz et al has conducted with 14.112 individuals tested for SARS-CoV-2 with known blood type in November 2020 found in New York Presbyterian

(NYP) hospital system. Results have showed that A,B and AB blood types have slightly increased infection prevalence than the O blood type . Especially blood type A has higher prevalence to infection than the other blood groups. When compare the blood groups for intubation, it was found that risk factor of the intubation prevalence is more higher in blood group B than the other groups. It also was found that blood group AB has most higher prevalence for risk of death than the other groups. Rh negative factor was found protective for risk of infection, intubation and death(27).

To reveal the association between blood groups and SARS-CoV-2 a study was carried out by Li et al in China. In a retrospective cohort study, which include 265 patients diagnosed with COVID-19 pneumonia in Wuhan Central Hospital, 39% are in blood group A, 25% are in the blood group B, 10% are in the blood group AB, and 26% are in the blood group O of the patients were reported. Also, blood group distributions are found as 32% blood type A, 25% blood type B, 9% blood type AB and 34% blood type O on 3694 healthy individuals. This results supports Zhao et al's data (28). It has been demonstrated that the rate of patients with blood group A diagnosed with COVID-19 is significantly higher than that of the control group, with a ratio of 39% to 32% (the rate of healthy individuals versus the patient). On the other hand, the rate of patients with blood group O was found significantly lower, compared to the control group, with 26% and 34% (the rate of healthy individuals versus the patient). These distributions were consistent in terms of age and gender according to blood groups. However, there was no significant difference in mortality rates compared to blood groups (28).

Peng et al. also conducted a retrospective study to understand the importance of the blood group in COVID-19 at the Public Hygiene Center at Taizhou Hospital in China between January 21, 2020 and February 20, 2020 (29). This study was conducted with 138 patients who diagnosed with COVID-19, and 82 patients with who undiagnosed with COVID-19. All the patients are compared in terms of blood groups distribution, gender distribution and severity of the disease (29). Diagnoses of the COVID-19 patients are based on Real Time PCR, CT radiography and clinical symptoms. While the average age of the patients was 50, 74 of the patients (53.6%) were male in terms of gender. Clinical symptoms were observed as 70.3% fever, 57.2% cough, 44% sputum removal, 22.5% weakness, 10.9% headache, diarrhea and chest pain (29). The blood group distributions of patients with COVID-19 are those who have severe disease; while 34.4% were in the blood group A, 34.4% were in the blood group B, 12.5% were in the blood group AB, 18.8% were in the blood group O, and are those who have mild disease; 28.3% were in blood group A, 27.4% were in blood group B, 11.3% were in blood group AB, 33.0% were in blood group O (29). The blood group distribution of those non-COVID-19 patients; it was reported that 26.8% were in the blood group A, 28.0% were in the blood group B, 7.3% were in the blood group AB, 37.8% were in the blood group O. As a result of the blood group distributions of the patients with COVID-19 and the statistical analysis, the risk of infection of the patients belonging to blood group O was found to be lower compared to other blood groups ($p = 0.044$) (29). Consequently, researchers have revealed that individuals with blood group O have a low risk of COVID-19 infection, especially in women with blood group O (29).

In addition to other studies, Zeng et al. conducted a research to determined the association between SARS-CoV-2 and blood groups on patients with COVID-19 from a total of 5 hospitals in the cities of Tianjin, Wuhan and Beijing in China (2). The diagnosis of COVID-19 of the hospitalized cases was made by positive real-time reverse transcriptase polymerase-chain-reaction (PCR) test of the nasal and pharyngeal swab samples taken from individuals. The blood groups of the patients were determined by the blood group test performed clinically. In the study, besides the blood group, the patients' age, gender, medical history, hospital reports and chest radiography were also taken. 137 patients with mild pneumonia and 97 patients with severe pneumonia were included in the study. The blood group AB was not included in the study, as it covered only a small proportion of the Chinese population, such as only 9% of the population, due to insufficient number of patients. When the patients were compared in terms of gender, 133 (56.8%) of 234 patients in total were male. When the patients are compared in terms of age, the age of 57-75 years, especially 67, is a critical age for the risk of infection. In this age and older age groups have a severe course of COVID-19, and most of the patients identified in the study were over 60 (73.2%). In addition, it was determined that patients between the ages of 40-64 (36.5%) had a mild infection compared to older age groups. Severe pneumonia was accompanied by acute distressed respiratory syndrome in approximately 67% of patients diagnosed with COVID-19 (2). The cause of death of patients in intensive care unit was recorded as multiple organ failure. When the association between COVID-19 and blood groups is examined, it was reported that 35.76% of patients with coronavirus with blood group A had mild infection and 39.22% of them had severe infection. Considering that a large part of the Chinese population consists of individuals with blood group A, it was found as a result of the study that individuals with this blood group were more susceptible to COVID-19 than other blood groups (2). Indeed, previous studies have revealed that the blood group O is the least susceptible to the SARS

virus (17). However in the new coronavirus study which is conducted by Zeng et al., the finding that blood group O had the least sensitivity could not be supported. Instead, they reported in their study that individuals with blood type A were more susceptible to SARS-CoV-2 infection. As the main reason for this may be the specific viral protein structure is thought to cause different susceptibility in different blood groups. Moreover, it was not found any significant effect on the mortality rates of different blood groups in their study. In addition to this, most of the patients with COVID-19, who have mild or severe symptoms, patients' blood type was found as blood type A. As a result, individuals with A blood group are more susceptible to COVID-19 infection than other blood groups (2).

In another study, which is conducted by Arac et al. (30), it was researched the association between COVID-19 and ABO blood group and Rh factor in a hospital in the city of Diyarbakir, Turkey. A total of 392 patients were included to the study. PCR test of the 227 patients, which are included to the study, were found as positive for SARS-CoV-2, and CT findings of the 165 patients in favor of COVID-19 (30). As a control group, 127,091 people' blood group data in Diyarbakır in 2019 were used. In the study, the blood group A was found to be higher in patients diagnosed with COVID-19, while B and AB blood groups, especially O, were lower. However statistical analysis showed no significant difference between COVID-19 patients and healthy individuals in terms of ABO blood group system (30). When analyzed in terms of Rh blood group system, it was found that Rh positivity was significantly higher in patients with COVID-19 (30). A study, which supports to this study, is conducted by Goker et al. at Hacettepe University in Ankara, Turkey. 186 PCR confirmed for COVID-19 patients and 1881 healthy individuals' blood group data included to the study. Most of the COVID-19 patients' blood groups were A (57%) was found. Result of the study has showed that blood group A might have effect in increased susceptibility to SARS-CoV-2 (COVID-19) and blood group O may have protective effect on COVID-19(26).

Clinical And Research Consequences: A literature search was performed in English databases including PubMed/Medline, ISI Web of Science, SCOPUS, and Google Scholar etc…from 2000 to March 2020. The following key words were used: COVID-19, ABO Blood Groups, ACE2, S Protein, etc..

CONCLUSION

The SARS-CoV-2 virus enters the target cells through an enzyme receptor, specifically called the angiotensin converting enzyme 2 (ACE 2), located on the surface of the lung alveolar cell. In addition to ACE2, CD147 and TMPRSS2 are two of the membrane proteins used by the virus to enter the cell. At this point, the S protein of SARS-CoV-2 acts as an important key for the virus to enter the host and transfers its genetic material to the target cell via membran proteins. In a related study, it was revealed that antibody A inhibits the binding of cells expressing S protein of the SARS-CoV to cells expressing ACE2 (22). Given the nucleic acid sequence (31) between SARS-CoV and SARS-CoV-2 (32, 33)and the similarity of binding to receptor angiotensin converting enzyme 2 (ACE2), the decreased susceptibility of the blood group O and the increased susceptibility of the blood group A for COVID-19 can be related with the presence of the specific Anti-A antibody in the blood.

Previous studies have revealed that the ABO blood group distribution also differs significantly in other viral infections (17). Indeed, Chen et al. reported that individuals with blood group O are less likely to become infected by the SARS coronavirus, and Batool et al. suggested that individuals belonging to blood group O may have developed a defense against blood-borne infections and while individuals with blood group A are more likely to become infected with the hepatitis B and HIV virus (34). Jing et al. found that individuals with B blood group had a low risk of catching Hepatitis B (35).

Guillon et al. reported that binding S proteins, which produced by SARS-CoV-2, to ACE2 receptors inhibits specifically by anti-A antibodies (22). That is, anti-A antibodies in the circulatory system can interrupt or inhibit the virus-cell adhesion process (22). This situation revealed that why the O blood group is not susceptible to infection and the A blood group is susceptible. Moreover Silva-Filho et al. has been found that sialic acid containing receptors, which induced by ABO antigens in host cells, maximize the interaction of the cells with COVID-19(4).

In the studies conducted, it was also examined whether the blood groups are susceptible to SARS-CoV-2 depending on the A antigen. However, in other studies conducted since the discovery that anti-A antibodies can inhibit virus-cell adhesion, blood groups B and O carrying anti-A antibodies in their serums were compared with the A and AB blood group patients who did not carry the anti-A antibody in terms of the prevalence of the disease (36). The results showed that the incidence of COVID-19 was lower in individuals with blood groups B and O with anti-A antibodies in their serum compared to individuals with A and AB blood groups who did not have anti-A antibodies in their serum (36). Subsequently, the blood group O with anti-A antibody was compared in terms of its protective effect against COVID-19 compared to the blood group B which carry the same antibody (36). The data obtained showed that anti-A antibodies in the blood group O had a more protective effect than the anti-A antibody in the blood group B. This result is probably related to the

fact that the immunoglobulin dominant isotype of anti-B/anti-A in the serum of individuals with A and B blood groups is IgM, and the immunoglobulin dominant isotype of the individuals with O blood group is IgG. That is, the presence of anti-A antibodies in the serum, and specifically the presence of IgG with Anti-A, is thought to be of greater importance in the susceptible to COVID-19 than the blood groups themselves (36).

Beside the all studies about susceptibility to SARS-CoV-2, several other studies also have shown that the A allele in the blood groups is associated with an increased risk of cardiovascular disease (37). The antigen A can protect P-selectin and intercellular cell adhesion molecule 1 (ICAM1) from enzymatic cleavage by promoting stronger and longer binding of leukocytes on the vascular wall. Therefore, more adhesion molecules connected to endothelial cells will increase adhesion and inflammation, while reducing circulation (38). While this makes the individuals with blood group A more likely to develop cardiovascular disease, individuals may develop multiple disease states when they are exposed to a redox stress such as a virus infection. Therefore, individuals with blood group O are less likely to develop cardiovascular diseases and severe COVID-19. In contrast, patients with blood type A, who have hypertension and accompanying heart disease, tend to have the disease quite severely once they are infected with COVID-19. Therefore, these individuals should be placed under special medical care in order to be quarantined and protected from SARS-CoV-2 infection as soon as possible (39).

Zietz et al has found association between blood groups and SARS-CoV-2. It was reported that increased infection prevalence was found especially in blood group A than B, AB and Rh+ blood groups. Increased intubation risk was showed in blood group B and AB. Also risk of death increased in blood groups AB than the other blood groups (27).

Clinical significance of blood groups that can be used as a biomarker regarding the susceptibility of individuals to COVID-19 as a result of the study conducted by Zhao et al.are; individuals with blood type A should provide more personal protection to reduce the risk of transmission, patients with SARS-CoV-2, which are blood type A, should get more observation and get the aggressive treatment, and finally as the introduction of ABO blood group classification to the system for manage the COVID-19 can be listed.

Consequently, association between blood groups and SARS-CoV-2 has been found in case of susceptibility to the COVID-19. Having different degrees of infection susceptibility of different blood groups means more protection of the individual who has the most susceptible blood group. Studies have showed that blood group A was found most susceptible to the COVID-19, and who have this blood group should be more careful and should use personal protective equipment for not get infected by the virus. Due to it is important to understand susceptibility of blood groups to COVID-19 for decrease the number of death cases. However it needs further investigation to enlighten the association between blood groups and SARS-CoV-2.

REFERENCES

1. Cooling L. Blood Groups in Infection and Host Susceptibility. Clinical microbiology reviews. 2015;28(3):801-70.
2. Zeng X, Fan H, Lu D, Huang F, Meng X, Li Z, et al. Association between ABO blood groups and clinical outcome of coronavirus disease 2019: Evidence from two cohorts. medRxiv. 2020.
3. Dzik S. COVID-19 convalescent plasma: now is the time for better science. Transfus Med Rev. 2020.
4. Silva-Filho JC, de Melo CGF, de Oliveira JLJMH. The influence of ABO blood groups on COVID-19 susceptibility and severity: a molecular hypothesis based on carbohydrate-carbohydrate interactions. 2020;144:110155.
5. Tirado SMC, Yoon K-J. Antibody-dependent enhancement of virus infection and disease. Viral Immunol. 2003;16(1):69-86.
6. Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. The Lancet. 2020;395(10223):507-13.
7. Zhao J, Yang Y, Huang H-P, Li D, Gu D-F, Lu X-F, et al. Relationship between the ABO Blood Group and the COVID-19 Susceptibility. medRxiv. 2020.
8. Li S-S, Zhou C-Y, Liao R, Xiong L, Weng N-N, Zhao Y-Q, et al. ABO blood type, smoking status, other risk factors and prognosis of pancreatic ductal adenocarcinoma. Medicine. 2020;99(14):e19413.
9. Davison GM, Hendrickse HL, Matsha TE. Do Blood Group Antigens and the Red Cell Membrane Influence Human Immunodeficiency Virus Infection? Cells-Basel. 2020;9(4):845.
10. Liumbruno GM, Franchini M. Beyond immunohaematology: the role of the ABO blood group in human diseases. Blood Transfus-Italy. 2013;11(4):491.
11. He M, Wolpin B, Rexrode K, Manson JE, Rimm E, Hu FB, et al. ABO blood group and risk of coronary heart disease in two prospective cohort studies. Arteriosclerosis, Thrombosis, and Vascular Biology. 2012;32(9):2314-20.

12.Meo S, Rouq F, Suraya F, Zaidi S. Association of ABO and Rh blood groups with type 2 diabetes mellitus. Eur Rev Med Pharmacol Sci. 2016;20(2):237-42.
13.Takayama W, Endo A, Koguchi H, Sugimoto M, Murata K, Otomo Y. The impact of blood type O on mortality of severe trauma patients: a retrospective observational study. Crit Care Med. 2018;22(1):100.
14.Gotsman I, Keren A, Zwas DR, Lotan C, Admon D. Clinical impact of ABO and rhesus D blood type groups in patients with chronic heart failure. The American journal of cardiology. 2018;122(3):413-9.
15.Shiratori F, Shimada H, Yajima S, Suzuki T, Oshima Y, Nanami T, et al. Relationship between ABO blood group and clinicopathological factors and their effect on the survival of Japanese patients with esophageal squamous cell carcinoma. Surgery today. 2017;47(8):959-65.
16.Rezoagli E, Gatti S, Villa S, Villa G, Muttini S, Rossi F, et al. ABO blood types and major outcomes in patients with acute hypoxaemic respiratory failure: A multicenter retrospective cohort study. Plos One. 2018;13(10):e0206403.
17.Cheng Y, Cheng G, Chui C, Lau F, Chan PK, Ng MH, et al. ABO blood group and susceptibility to severe acute respiratory syndrome. Jama Cardiol. 2005;293(12):1447-51.
18.Loscertales MP, Owens S, O'Donnell J, Bunn J, Bosch-Capblanch X, Brabin BJ. ABO blood group phenotypes and Plasmodium falciparum malaria: unlocking a pivotal mechanism. Advances in parasitology. 2007;65:1-50.
19.Boren T, Falk P, Roth KA, Larson G, Normark S. Attachment of Helicobacter pylori to human gastric epithelium mediated by blood group antigens. Sci Educ-Netherlands. 1993;262(5141):1892-5.
20.Lindesmith L, Moe C, Marionneau S, Ruvoen N, Jiang X, Lindblad L, et al. Human susceptibility and resistance to Norwalk virus infection. Nat Med. 2003;9(5):548-53.
21.Wang DS, Chen DL, Ren C, Wang ZQ, Qiu MZ, Luo HY, et al. ABO blood group, hepatitis B viral infection and risk of pancreatic cancer. International journal of cancer. 2012;131(2):461-8.
22.Guillon P, Clément M, Sébille V, Rivain J-G, Chou C-F, Ruvoën-Clouet N, et al. Inhibition of the interaction between the SARS-CoV spike protein and its cellular receptor by anti-histo-blood group antibodies. Glycobiology. 2008;18(12):1085-93.
23.Zietz M, Tatonetti, P N. Testing the association between blood type and COVID-19 infection, intubation, and death. medRxiv. 2020.
24.Medicine SC-GGJNEJo. Genomewide association study of severe Covid-19 with respiratory failure. 2020;383(16):1522-34.
25.Wu B-B, Gu D-Z, Yu J-N, Yang J, Shen W-QJI, Genetics, Evolution. Association between ABO blood groups and COVID-19 infection, severity and demise: A systematic review and meta-analysis. 2020;84:104485.
26.Göker H, Karakulak EA, Demiroğlu H, Ceylan ÇMA, Büyükaşik Y, Inkaya AÇ, et al. The effects of blood group types on the risk of COVID-19 infection and its clinical outcome. 2020;50(4):679-83.
27.Zietz M, Zucker J, Tatonetti NPJNc. Associations between blood type and COVID-19 infection, intubation, and death. 2020;11(1):1-6.
28.Li J, Wang X, Chen J, Cai Y, Deng A, Yang M. Association between ABO blood groups and risk of SARS-CoV-2 pneumonia. Brit J Haematol. 2020.
29.Peng M, Huang S, Zhu S, Chen C, Qin J, He M, et al. Distribution of ABO blood groups and association to low risk of COVID-19 infection in patients. Translational Medicine. 2020.
30.Esref A, SOLMAZ I, AKKOC H, DONMEZDIL S, KARAHAN Z, Safak K, et al. Association Between the Rh Blood Group and the Covid-19 Susceptibility. Int J Hematol. 2020;30(2):081-6.
31.Lu R, Zhao X, Li J, Niu P, Yang B, Wu H, et al. Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. The Lancet. 2020;395(10224):565-74.
32.Hoffmann M, Kleine-Weber H, Krüger N, Mueller MA, Drosten C, Pöhlmann S. The novel coronavirus 2019 (2019-nCoV) uses the SARS-coronavirus receptor ACE2 and the cellular protease TMPRSS2 for entry into target cells. BioRxiv. 2020.
33.Wan Y, Shang J, Graham R, Baric RS, Li F. Receptor recognition by the novel coronavirus from Wuhan: an analysis based on decade-long structural studies of SARS coronavirus. J Virol. 2020;94(7).
34.Batool Z, Durrani SH, Tariq S. Association of ABO and Rh blood group types to hepatitis B, hepatitis C, HIV and Syphillis infection, a five year'experience in healthy blood donors in a tertiary care hospital. Journal of Ayub Medical College Abbottabad. 2017;29(1):90-2.
35.Jing W, Zhao S, Liu J, Liu M. ABO blood groups and hepatitis B virus infection: a systematic review and meta-analysis. Bmj Open. 2020;10(1).
36.Gérard C, Maggipinto G, Minon JM. COVID-19 & ABO blood group: another viewpoint. Brit J Haematol. 2020.
37.Wu O, Bayoumi N, Vickers M, Clark P. ABO (H) blood groups and vascular disease: a systematic review and meta-analysis. J Thromb Haemost. 2008;6(1):62-9.

38.Paré G, Chasman DI, Kellogg M, Zee RY, Rifai N, Badola S, et al. Novel association of ABO histo-blood group antigen with soluble ICAM-1: results of a genome-wide association study of 6,578 women. PLoS Genet. 2008;4(7):e1000118.
39.Dai X. ABO blood group predisposes to COVID-19 severity and cardiovascular diseases. Eur J Prev Cardiol. 2020;27(13):1436-7.