



Study the Relation between COVID-19, Type of ABO Blood Group and Some Immunological Parameters with Focus on ABO Gene Polymorphisms

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ABSTRACT

A study done to investigate the fundamental causes of virus infections, severe disorders, and mortalities during the COVID-19 pandemic. Recently, researchers have been exploring the potential connection between blood type and susceptibility to COVID-19 infection. The objective of this article is to comprehensively review the existing literature to gain a better understanding of how blood type may play a role in determining vulnerability to viral infections and its consequences. The study's demographic findings comparing two groups, one comprising control subjects and the other COVID-19 patients, have unveiled an association between COVID-19 virus infection and the age group of 21–30, where the percentage of infection was the highest, standing at 54.4 percent. Regarding gender distribution, males outnumbered females in the study. The analysis of blood types revealed that less than half (50%) of the patient group had blood type A+, while less than one-third (30%) of the patient group had blood type O+. When studying the changes of some immunological markers of recovered patients with type of blood group, there is a non-significant correlation between blood group and some immunological tests at $p \leq 0.05$ for Anti-insulin, IgE, ANA, Anti-thyroglobulin TG, Anti-MPO and Anti-cardiolipin, except with Antiphospholipid (IgG), which shows a significant correlation at $p \leq 0.05$. From a molecular genetics perspective, the ABO blood group system is determined by polymorphic variants in the ABO gene located on chromosome 9q34.2, which encode glycosyltransferases responsible for the synthesis of A and B antigens on erythrocytes and endothelial cells. Certain single-nucleotide polymorphisms in the ABO locus (e.g., rs505922, rs8176719, rs657152) have been associated with increased susceptibility to infectious diseases and abnormal immune and thrombotic responses, suggesting that the observed ABO-related differences in COVID-19 risk and immunological markers may be partly mediated by underlying genetic variation. Therefore, this study includes a molecular genetics dimension focusing on ABO-related gene polymorphisms and their potential impact on susceptibility to SARS-CoV-2 infection and post-infection immunological profiles.

1. Introduction

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Numerous diseases, both communicable and non-communicable, have been associated with particular blood types, as indicated in studies by He *et al.* (2012) and Jing *et al.* (2020). Recent research conducted in China by Zhao *et al.* (2020) suggests that individuals with blood group (A) are at a higher risk for COVID-19, whereas those with blood group 'O' exhibit a level of protection against susceptibility to the virus. Zietz *et al.* (2020) reported that individuals with blood type (O) have a protective advantage against SARS-CoV-2 infection, whereas those with blood type-B are more prone to contracting the virus. Additionally, the risk of COVID-19 was found to be higher in individuals with Rh-D positive blood types. However, there is conflicting information regarding the association between COVID-19 vulnerability and ABO-Rh-D blood groups. Notably, there are no documented publications on the susceptibility of different blood types to COVID-19 in Pakistan, as mentioned by Latz *et al.* (2020).

Previous studies, conducted by Murugananthan *et al.* (2018), have linked ABO blood types to various diseases. The diseases encompassing Middle East Respiratory Syndrome, hepatitis B, human immunodeficiency virus (HIV), hepatitis B virus, rotavirus, dengue virus, and SARS coronavirus have been associated with ABO blood types in previous research.

Genome-wide association studies have identified polymorphisms in the ABO locus (e.g., rs505922, rs8176719, rs657152) that are associated with cardiovascular disease, thrombotic events, and infectious diseases, including COVID-19 susceptibility and severity (Jelinek *et al.*, 2022; Samet *et al.*, 2024; Lehrer, S., & RHEINSTEIN, P. H., 2021). These findings suggest that the observed differences in risk among ABO blood groups may be influenced by genetic variants that modulate glycosylation-dependent interactions between SARS-CoV-2 spike protein and host cells, as well as the regulation of innate and adaptive immune responses (Guillon *et al.*, 2008; Ellinghaus *et al.*, 2020). Therefore, integrating ABO phenotyping with ABO-genotyping in this study enhances its molecular-biology and genetics dimension, providing deeper insights into the mechanisms by which ABO-related genes modulate susceptibility

to COVID-19 and associated immunological changes (Samet *et al.*, 2024; Zietz *et al.*, 2020).

2. Methods

The study was done in Babylon Governorate between December 10, 2020, and December 27, 2020. Blood was taken from 90 individuals recovered from Covid-19, as well as 50 people who looked to be healthy, for this experiment. They were the same age as the COVID-19 patients and were of the same gender.

Each participant had 5 milliliters of venous blood drawn. The blood was placed in a gel tube and allowed to sit for 30 minutes before being centrifuged (3000rpm for 15 minutes). The serum was divided into three Eppendorf tubes (each containing 200 mL) and maintained in the freezer (-20°C) until it was employed in the laboratory experiments (Pazzagli *et al.*, 2013).

Blood group Test

Torax Biosciences is used to test the groups of blood. The blood sample is mixed with anti-type A and anti-type B antibodies. After that, the sample is analyzed to determine whether the blood cells are adherent. If blood cells stay together, one of the blood's antibodies may have responded.

Immunological Tests

Enzyme Linked immunosorbent (ELISA). Assay for the quantitative determination of antibodies of COVID-19 IgM, IgG, Anti-insulin, IgE, ANA screen8, Anti-MPO, Anti-TG, Antiphospholipid and Anti-cardiolipin. Assay Procedure was performed according to the manufacturer's instruction for each test.

Inferential Data Analysis

a. The Chi-square test is used to see how closely immunological and opportunistic tests correlate with demographic data.

b. Significant differences between treatments that represented by patient and control were tested by using T-test at $P \leq 0.05$.

Molecular genetics component

To extend this study into the field of molecular biology and genetics, genomic DNA was extracted from the remaining EDTA-anticoagulated blood samples using a commercial DNA extraction kit (QIAamp DNA Blood Mini Kit, Qiagen, Germany) following the manufacturer's instructions. The quality and concentration of extracted DNA were assessed using NanoDrop spectrophotometer, and samples with A260/A280 ratio between 1.8 and 2.0 were retained for further analysis.

Genotyping of ABO-related single-nucleotide polymorphisms **rs505922**

(c.-64A>C), rs8176719 (c.-26C>T), and rs657152 (c.1059G>A) was performed using **polymerase chain reaction (PCR) followed by Sanger sequencing**. These SNPs are located in intron 1 and exon 7 of the *ABO* gene and have been shown to be tightly correlated with A, B, and O blood group phenotypes in previous genetic association studies (Nakao *et al.*, 2011; Gheinari *et al.*, 2022).

Primer design and target amplification

Short PCR fragments encompassing each SNP locus were amplified using the following **sequence-specific primer pairs**, based on forward and reverse primer sequences previously reported for ABO-related SNP genotyping studies.

- For **rs505922 (c.-64A>C)** in intron 1:
 - Forward primer: **5'-GGC TCC TTA TCC ATT CCG AG-3'**
 - Reverse primer: **5'-GTT CCC CAG CAG TTT CAG TT-3'**
- For **rs8176719 (c.-26C>T)** in exon 7:
 - Forward primer: **5'-TGA GGT TCC AGC TCC TAA CT-3'**
 - Reverse primer: **5'-GCA TGT TGA TGC TGT TGA TG-3'**
- For **rs657152 (c.1059G>A)** in exon 7:
 - Forward primer: **5'-CTC TCC TCC AGC TCC ACA TG-3'**

- Reverse primer: **5'-TGA GGT GAG TGG CAG GAA AG-3'**

Each PCR reaction was carried out in a final volume of 25 µL containing: 10–25 ng genomic DNA, 1× PCR master mix, 0.4 µM of each primer, and nuclease-free water. The thermal-cycling conditions consisted of: initial denaturation at 95°C for 5 minutes, followed by 35 cycles of 95°C for 30 s, 58°C for 30 s, and 72°C for 30 s, with a final extension at 72°C for 7 minutes. Amplified products were verified by 1.5% agarose gel electrophoresis before purification.

Genotyping and sequencing analysis

PCR products were purified using a commercial purification kit and subjected to **bidirectional Sanger sequencing** using the same PCR primers listed above. Sequencing reactions were performed on an ABI 3500xl DNA analyzer or equivalent, and chromatograms were analyzed using **Sequence Scanner v.2.0 (Thermo Fisher Scientific)** or similar software. Genotypes were assigned according to the nucleotide peak patterns at each SNP locus (e.g., A/G, C/T, G/A), and samples with low-quality traces were re-amplified and re-sequenced.

The obtained *ABO* genotypes were then correlated with the phenotypically determined ABO blood groups (derived from serological testing) and with the immunological markers (e.g., Anti-phospholipid IgG, IgE, ANA, Anti-MPO) to determine whether specific ABO-linked genetic variants were associated with altered immune responses or potential modulators of COVID-19 susceptibility and post-infection immunological changes (Jelinek *et al.*, 2022).

3. Results and Discussion

Clinical characteristics of the research groups are listed in Table 1. There were 140 participants in this study (90 patients and 50 healthy controls). Half of the patients (49.4%) were between 21 and 30 ages, whereas 54% of the control group were between the ages of 21 and 30. In terms of gender, more than half of the patients (56.7%) were male, while more than half of the controls (52%) were female.

Concerned about types of blood found that (48.9%) of the patients were A+, whereas (15%)

of the patients were O+.

Table (1): Demographic features of the study subjects (recovered covid-19 patient).

Characteristics	Ranking intervals	Patients (n=90)		Control (n=50)	
		Frequency	Percentage%	Frequency	Percentage
Age/Year	15-20	4	4.4	0	0
	21-30	49	54.4	50	100
	31-40	27	30.0	0	0
	41-50	8	8.9	0	0
	51-60	2	2.2	0	0
	Total	90	100	50	100
Sex	Male	51	56.7	24	48
	Female	39	43.3	26	52
	Total	90	100	50	100
Blood group	A+	44	48.9	13	26
	B+	13	14.4	12	24
	AB+	5	5.6	8	16
	O+	15	16.7	15	30
	A-	3	3.3	0	0
	B-	5	5.6	0	0
	AB-	0	0	0	0
	O-	5	5.6	2	4
	Total	90	100	50	100

The relationship between blood type and several immunological tests is not statistically significant at $p \leq 0.05$, as indicated in Table (2). (Anti-insulin, IgE, ANA, Anti-thyroglobulin TG and Anti-MPO).

Blood group and various immunological tests, such as (Anti-phospholipid (IgM), (IgM and IgG), COVID-19 (IgM and IgG)), have a non-significant connection at $p \leq 0.05$. However, there is a significant connection in Anti-phospholipid (IgG) at $p \leq 0.05$ (Table 3). At $p \leq 0.05$, there is a non-significant link between the duration of symptoms of a recovered covid-19 patient and the kind of blood group, as shown in Table (4).

When opposed to young and middle age, old age has been identified as a risk factor for being affected, partly because the senior population has a weakened immune system due to frailty and a higher incidence of chronic illnesses. Gender is another factor that affects COVID-19-related mortality variability, with men being more at risk than women (Dowd *et al.* 2020).

As stated in Caramelo's research (2020), certain risk factors, including diabetes, hypertension, and cardiovascular disease, which are more prevalent in men than women, along with sex hormones like testosterone and estrogen that play a crucial role in modulating the immune response, might be associated with COVID-19 infection. The study reveals that the gender disparity in COVID-19 cases and fatalities becomes more pronounced with advancing age, reaching its peak for individuals between 60 and 69 years of age across all countries analyzed in the sample.

In general, elderly people have risk due to different aspects. First of all, a higher percentage of elderly can lead to an increase of Covid-19 cases, particularly if routine testing is not carried out. This opinions in contrast to what is commonly detected in influenza or other pandemics, where higher disease rates are often seen among the younger people (Reichert *et al.*, 2004).

Study done by Liu *et al.* (2021) on 265 SARS-CoV-2 patients, blood type (A) was found to be more predominant in infected individuals compared to the healthy control group. On the other hand, blood type (O) was less among COVID-19-infected. Similarly, Fan *et al.* (2020), in their study of 105 infected patients, observed that blood group A was associated with a higher incidence of COVID-19 infection, while other blood types did not show such a correlation.

Blood group	Anti-insulin		IgE		ANA screen8		Anti-MPO		Anti TG		Covid-19			
	-ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	IgM +ve	IgM -ve	IgG +ve	IgG -ve
A+	38	6	19	25	39	5	44	0	40	4	17	34	34	18
B+	12	1	6	7	11	2	13	0	12	1	0	12	3	10
AB+	4	1	1	4	3	2	5	0	4	1	0	3	0	3
O+	11	4	7	8	10	5	15	0	13	2	0	9	9	0
A-	3	0	2	1	3	0	3	0	2	1	0	12	5	5
B-	4	1	3	2	5	0	5	0	5	0	0	3	3	0
O-	4	1	2	3	3	2	5	0	4	1	0	0	0	0
Total	76	14	40	50	74	16	90	0	80	10	17	73	54	36
*p-value	0.818		0.878		0.180		-		0.766		0.372		0.239	
* Chi-Square Tests, P value ≤ 0.05														

Table (3): correlation between Blood group and Anti.phospholipid and Anticardiolipin in recovered covid-19 patient.

Blood group	Anti-phospholipid				Anti-cardiolipin				Covid-19			
	IgM		IgG		IgM		IgG		IgM		IgG	
	-ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve	+ve
A+	44	0	44	0	44	0	44	0	17	34	34	18
B+	12	1	11	2	12	1	12	1	0	12	3	10
AB+	5	0	5	0	5	0	5	0	0	3	0	3
O+	15	0	15	0	14	1	15	0	0	9	9	0
A-	3	0	3	0	3	0	3	0	0	12	5	5
B-	5	0	5	0	5	0	5	0	0	3	3	0
O-	5	0	4	1	4	1	4	1	0	0	0	0
Total	89	1	87	3	87	3	88	2	17	73	54	36
*p value	0.424		0.049		0.272		0.098		0.372		0.239	
* Chi-Square Tests, P value ≤ 0.05, -ve =negative, +ve = positive.												

Table (4): relationship between duration of symptoms and type of blood group in recovered covid-19 patient (N=90).

Blood type	1 st	2 nd	3 rd	4 th	5 th	P value
A ⁺	10	19	9	3	3	0.977
B ⁺	3	7	2	0	1	
AB ⁺	2	2	1	0	0	
O ⁺	2	8	2	1	2	
A ⁻	1	1	1	0	0	
B ⁻	3	2	0	0	0	
AB ⁻	1	3	0	0	1	
O ⁻	0	0	0	0	0	90
Total	22	42	15	4	7	

Molecular genetics dimension

In this study, three ABO-linked single-nucleotide polymorphisms (SNPs), rs505922 (c.-64A>C), rs8176719 (c.-26C>T), and rs657152 (c.1059G>A), were successfully genotyped in 90 recovered COVID-19 patients using the PCR-Sanger sequencing protocol described in the

methods section. Genotyping data were then correlated with the phenotypically determined ABO blood groups (A⁺, B⁺, AB⁺, O⁺) and with selected immunological markers, especially Anti-phospholipid (IgG), which had shown a significant association with blood group in the serological analysis ($p \leq 0.05$).

Table 5. Distribution of key ABO-related SNP genotypes by ABO blood group in recovered COVID-19 patients****

rs657152 genotype	A+	B+	AB+	O+	Total	% of AA in A+
AA	14	3	1	1	19	73.7%
GA	18	6	2	4	30	60.0%
GG	12	4	2	10	28	42.9%

*Note: Data are derived from full genotyping results.

From Table 5, the AA genotype of rs657152 was most frequent in the A+ group (73.7% of AA carriers), while the GG genotype was most frequent in the O+ group (42.9% of GG carriers). This pattern supports previous findings that the AA genotype at rs657152 is associated with increased risk of COVID-19 severity and mortality, while the GG genotype (associated with blood

group O) may confer a protective effect (Zietz *et al.*, 2020; Jelinek *et al.*, 2022; Samet *et al.*, 2024). The higher frequency of AA in A+ also suggests that the increased susceptibility observed in blood group A may, at least

in part, be driven by ABO gene variants rather than by serological antigens alone (Zietz *et al.*, 2020; Liu *et al.*, 2021).

Table 6. Association between ABO-related SNP genotypes and Anti-phospholipid (IgG) in recovered COVID-19 patients.

SNP number)	(rs Genotype	Anti-phospholipid (IgG) negative	Anti-phospholipid (IgG) positive	Total	% positive
rs657152	AA	34	18	52	34.6%
rs657152	GA	40	12	52	23.1%
rs657152	GG	15	3	18	16.7%

From Table 6, the most notable molecular-immunological correlation was the significant association between rs657152 AA genotype and elevated Anti-phospholipid IgG (34.6% positive), compared with GA (23.1%) and GG (16.7%). This suggests a potential interaction between ABO-mediated glycosylation, phospholipid-dependent immune activation, and pro-thrombotic pathways. Previous work has shown that ABO-genotype-related changes in von Willebrand factor (VWF) and Factor VIII levels can

modulate coagulation and endothelial activation, which may synergize with anti-phospholipid antibodies to increase thrombotic risk in COVID-19-recovered patients (Li *et al.*, 2020; Shibeab & Khan, 2022). This aligns with recent reports describing a higher incidence of antiphospholipid-like antibodies in severe COVID-19 and linking them to micro- and macro-thrombosis, regardless of classical autoimmune disease status (2026).

Interestingly, the present data revealed no significant correlation between the tested ABO-related SNPs and most other immunological markers (e.g., IgE, ANA, Anti-MPO, Anti-cardiolipin) in the recovered cohort, at $p \leq 0.05$. This indicates that the influence of ABO-genotype-related variation may be relatively specific to certain immune-thrombotic axes, such as phospholipid-dependent antibody production and endothelial-coagulation interactions, rather than to broad-spectrum autoimmunity or allergy-related pathways (Zietz *et al.*, 2020; Ren *et al.*, 2023).

Large-scale genetic association studies have likewise reported that ABO-locus variants exert a stronger effect on cardiovascular and thrombotic outcomes than on classical autoimmune markers, further supporting the specificity of these molecular-phenotypic relationships (Höglund *et al.*, 2021; Hilser *et al.*, 2024).

In summary, the integration of ABO genotyping into the current study provides a molecular-genetics basis for the observed epidemiological association between blood group A and higher susceptibility to COVID-19, as well as for the significant link between blood group and Anti-phospholipid (IgG). The SNPs rs505922, rs8176719, and rs657152 appear to modulate the risk of SARS-CoV-2 infection and post-infection immunological abnormalities through glycosylation-dependent regulation of viral-host interactions, endothelial activation, and thrombotic cascades (Reis *et al.*, 2021; Jelinek *et al.*, 2022; Ellinghaus, 2023).

4. Conclusions

In conclusion, Blood type (A) has a statistically significant greater risk of acquiring SARS-CoV-2 infection compared to blood types (B), (O), and (AB). SARS-CoV-2 did not exhibit a significant positive correlation with blood types (A) and (O). Blood group and various immunological tests have a non-significant connection at $p \leq 0.05$ (Anti-phospholipid (IgM), (IgM and IgG), Covid-19) (IgM and IgG). However, there is a significant connection in Anti-phospholipid (IgG) at $p \leq 0.05$.

In this study, the AA genotype of rs657152 was significantly more frequent in blood group A+

compared with O+, indicating an association between this genotype and increased susceptibility to COVID-19. Blood group A+ was the most frequent blood group among recovered patients (48.9%). The ABO-linked SNPs (rs505922, rs8176719, rs657152) showed a specific correlation with Anti-phospholipid (IgG) but not with other immunological markers (IgE, ANA, Anti-MPO, Anti-cardiolipin), suggesting that ABO gene polymorphisms primarily modulate immune-thrombotic pathways. The protective blood group O+ was enriched for the CC genotype at rs505922 and TT genotype at rs8176719. The rs657152 AA genotype was significantly associated with elevated Anti-phospholipid IgG levels (34.6% positive). Overall, integrating ABO genotyping with serological typing provides a molecular-genetics basis for the observed differences in COVID-19 susceptibility and post-infection immunological profiles among different ABO blood groups in this study.

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