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Association of ABO Blood Groups with Glycemic Control and Renal Markers in Diabetic Patients with COVID-19: A Cross-Sectional Study from Iraq (2020–2021)

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ABSTRACT

Background: Diabetes mellitus is a significant risk factor for adverse outcomes in COVID-19. ABO blood groups have been proposed to influence susceptibility and clinical outcomes in infectious diseases. Nevertheless, the evidence indicates a limited relationship between ABO blood groups and metabolic/renal markers in diabetic patients with COVID-19. Objective: The aim was to determine ABO blood group distribution and their association with glycemic control and renal function markers in diabetic patients diagnosed with COVID-19 in Iraq. Methods: A cross-sectional study was performed at Al-Mustansiriyah Diabetes Center, Iraq, 2020--2021. Patients with diabetes who had confirmed COVID-19 were included. Blood-group distribution of ABO was described. Glycemic control markers (HbA1c and fasting plasma glucose) and renal-related markers (serum urea, creatinine, and uric acid) were reported using mean ± SD. Analytical analyses were conducted to study associations between ABO blood groups, HbA1c, and biochemical variables. Results: 87 people with diabetic COVID-19 were enrolled. ABO groups were divided by blood group: B (n=28), A (n=25), O (n=18), and AB (n=13), with few Rh-negative groups (A− n=1, B− n=2). Mean HbA1c was 9.13 ± 1.83%, mean age was 55.4 ± 12.1 years and mean fasting plasma glucose 229.38 ± 92.91 mg/dL.

No significant differences were found across ABO blood groups for any biochemical marker. HbA1c presented a positive relationship with fasting plasma glucose and negative associations with renal markers, serum urea, creatinine, and uric acid. In the diabetic patients with COVID-19, ABO blood groups B and A were the most common. Measures of glycemic control were associated with renal-related biochemical markers: this indicates a potential metabolic-renal interplay in the case of this population. More extensive studies using larger samples are required to further investigate the relevant role played by ABO blood groups in the clinical outcome of diabetic COVID-19 patients.

1. Introduction

COVID-19 has become one of the most severe challenges to health systems worldwide. Chronic conditions including diabetes are associated with a high risk for severe infection[1,2]. Since the control of blood glucose and other blood parameters is an important part of early patient recovery, there is an urgent requirement to determine if any association exists between blood parameters/status and outcomes of COVID-19 disease[3,4]. Glycaemic regulation is an important parameter in individuals with diabetes. Tracking of glycemic control has the potential to provide information regarding long-term diabetes status. Glycemic control also serves as a parameter to gauge whether threshold metabolic targets are met. Parameters such as glycated hemoglobin (HbA1c) and fasting plasma glucose are accepted gauge indicators of glycaemic control. Renal functions have attracted significant research attention since COVID-19, as acute kidney injury has been observed when COVID-19 patients present for treatment[6,7]. Blood parameters of COVID-19 infection and diabetic patients in Iraq are not well explored, and the relationship of ABO blood groups with these blood markers is unknown.

Apart from the metabolic drivers, ABO blood groups have been studied as potential biological determinants for susceptibility to infectious diseases like COVID-19. There has been debate on the effect of ABO blood group antigens on viral entry mechanisms, inflammatory pathways, thrombosis risk, and immune response. However, the available evidence is mixed, and the link between ABO blood groups and biochemical markers is not well established in diabetic patients with COVID-19, especially those from Middle Eastern populations[10,11]. The specific objectives were to determine the distribution of ABO blood groups in Iraqi COVID-19-infected diabetic patients, to assess the association between ABO blood groups and glycemic control parameters (HbA1c, fasting plasma glucose), and to evaluate the association between ABO blood groups and renal markers like: creatinine and urea in addition to uric acid in this population.

2. Materials and Methods

2.1 Study design and setting: A cross-sectional study was carried out at Al-Mustansiriyah Diabetes Center, Iraq from 2020 to 2021 including patients with diabetes diagnosed with COVID-19.

2.2 Study population: This was a cohort study of adult diabetic individuals with confirmed COVID-19 status who attended or were managed at the diabetes center during the study. The following variables were extracted: Demographic data: age (mean ± SD), ABO blood group (A, B, AB, O; Rh-negative categories were documented but limited in number); Glycemic control markers: HbA1c and fasting plasma glucose (FPG); Renal-related markers: serum urea, serum creatinine, serum uric acid. Laboratory measurements were performed at two time points. Baseline examination (Time Point 1) was taken during the

Table 1. Distribution of ABO blood groups among diabetic patients with COVID-19 (n = 87)

Blood group	Frequency (N)	Percentage (%)
A	25	28.7
B	28	32.2
AB	13	14.9
O	18	20.7
A-	1	1.1
B-	2	2.3
Total	87	100.0

Rh-negative groups are shown separately; percentages are based on total cohort.

Table 2. Mean age by ABO blood group

Blood group	Mean age (years)± SD
A	55.7± 11.9
B	54.3± 12.4
AB	54.02± 12
O	57.50± 10.8
A-	60.00
B-	65.00

SD not calculated for Rh-negative groups because of small sample sizes.

Note: Age did not differ significantly among ABO blood groups (p = 0.62, Kruskal–Wallis test).

initial clinical examination; the secondary evaluation (Time Point 2) was done around 8-12 weeks later, which is the biological interpretation window of HbA1c. HbA1c1 and HbA1c2 were defined by[13] as the baseline and follow-up HbA1c measurements respectively.

Inclusion criteria

- Patients with diabetes mellitus (diagnosis type 1 or 2).
- Confirmed infection of COVID-19 during 2020--2021.
- Availability of ABO blood group data.
- Availability of important laboratory investigations (HbA1c, FPG, renal markers).

Exclusion criteria

- Patients with incomplete laboratory data for primary outcomes.
- Patients with missing ABO blood group classification.
- Patients with conditions that would seriously compromise renal markers (e.g., end-stage renal disease).
- Patients with significant comorbidities (e.g., stage 4-5 chronic kidney disease, active malignancy, liver cirrhosis) that could independently modify glycemic conditions or renal parameters to avoid confounding.
- Participant age was considered in the analysis to ensure it did not act as a confounding factor.

2.3 Data acquisition involved gathering information from existing clinical and laboratory documentation.

2.4 The principal outcome of this investigation centered on the correlation between ABO blood groups and biochemical indicators, specifically those related to glycemic control (HbA1c, FPG) and renal function/metabolic renal stress (urea, creatinine, uric acid).

Table 3. The biochemical profile of diabetic patients with COVID-19

Parameter	Time point	Mean ± SD
HbA1c (%)	1	9.13±1.83
HbA1c (%)	2	8.54±1.49
Fasting plasma glucose (mg/dL)	1	229.38±92.91
Fasting plasma glucose (mg/dL)	2	161.00±31.22
Serum urea (mg/dL)	1	34.44±15.59
Serum urea (mg/dL)	2	29.18±10.69
Serum creatinine (mg/dL)	1	0.78±0.40
Serum creatinine (mg/dL)	2	0.72±0.42
Serum uric acid (mg/dL)	1	4.98 ± 2.30
Serum uric acid (mg/dL)	2	4.08 ± 1.27

Time point 1 = baseline; time point 2 = follow-up (8–12 weeks). HbA1c: glycated hemoglobin; SD: standard deviation.

2.5 Statistical analysis: Analysis of data was performed using IBM SPSS Statistics for Windows, version 31.0 (IBM Corp., Armonk, NY, USA). Blood groups (categorical variables) were indicated as frequencies and percentages. Mean ± standard deviation (SD) was reported for continuous variables. Normality of distribution was tested by the Shapiro--Wilk test. For continuous variable comparisons among ABO blood groups, one-way ANOVA tests were used to compare normally distributed data with Kruskal--Wallis tests for non-normal distributions. Correlation analysis (Pearson or Spearman as appropriate) was performed to evaluate the relationships between HbA1c with renal-related markers and FPG. $P < 0.05$ was considered statistically significant. Additionally, the relationship between age and continuous biochemical markers was assessed using Spearman's rank correlation coefficient due to the non-normal distribution of some variables.

2.6 Ethical considerations: The proposal of this study was checked and approved by the Ethics Committee at Al-Mustansiriyah University's College of Pharmacy. We used data from patient records at the Al-Mustansiriyah Diabetes Center, but we made sure to keep everything anonymous. This meant that we didn't collect any personal details that could identify the patients. Before we started collecting data, all the participants agreed to take part by giving their electronic consent. They had to actively choose to agree by selecting the "I agree" option. We followed all the ethical rules for doing research with human subjects, and we made sure to protect everyone's confidentiality.

3. Results

3.1 Distribution of ABO blood group: 87 diabetic patients having COVID-19 were included. ABO Blood Group Distribution indicated that group B was most representative (n = 28, 32.2%), followed by A (n = 25, 28.7%), O (n = 18, 20.7%), and AB (n = 13, 14.9%). Rh-negative blood was rare (A– n = 1, B– n = 2) (Table 1). This distribution, characterized mainly by groups B and A, contrasts with the global pattern where group O tends to be most prevalent. Nonetheless, it aligns with earlier findings regarding the distribution of blood groups in Iraqi populations.

3.2 Age distribution among the blood groups: The mean age of the total cohort was 55.4 ± 12.1 years (mean ± SD). Average age differed slightly among

Table 4A. Correlation of HbA1c (time point 1) with biochemical parameters

Parameter	Correlation coefficient	P-value
FPG 1	0.632	<0.001
FPG 2	0.714	<0.001
Serum creatinine 1	−0.387	0.008
Serum creatinine 2	−0.387	0.008
Serum urea 1	−0.676	<0.001
Serum urea 2	−0.676	<0.001
Serum uric acid 1	−0.703	<0.001
Serum uric acid 2	−0.708	<0.001

Spearman's rank correlation coefficient used due to non-normal distribution of some variables. FPG: fasting plasma glucose. p < 0.05 considered statistically significant.

Table 4B. Correlation of HbA1c (time point 2) with biochemical parameters

Parameter	Correlation coefficient	P-value
FPG 1	0.646	<0.001
FPG 2	0.750	<0.001
Serum creatinine 1	−0.310	0.043
Serum creatinine 2	−0.303	0.048
Serum urea 1	−0.783	<0.001
Serum urea 2	−0.755	<0.001
Serum uric acid 1	−0.752	<0.001
Serum uric acid 2	−0.731	<0.001

Spearman's rank correlation coefficient used due to non-normal distribution of some variables. FPG: fasting plasma glucose. p < 0.05: statistically significant.

Table 4C. Correlation of age with biochemical parameters

Parameter	Correlation coefficient	P-value
HbA1c1	0.11	0.33
HbA1c2	0.09	0.45
FPG 1	0.07	0.52
FPG 2	0.13	0.23
Serum urea 1	0.05	0.66
Serum urea 2	0.06	0.61
Serum creatinine1	0.08	0.48
Serum creatinine2	0.07	0.54
Serum uric acid 1	-0.02	0.83
Serum uric acid 2	-0.01	0.91

Spearman's rank correlation coefficient used due to non-normal distribution of some variables. FPG: fasting plasma glucose. p < 0.05: statistically significant.

Table 5. Biochemical parameters by ABO blood group among diabetic patients with COVID-19 (n = 87)

Parameter	Blood Group A (n=25)	Blood Group B (n=28)	Blood Group AB (n=13)	Blood Group O (n=18)	p-value
HbA1c1 (%)	8.95 ± 1.76	9.24 ± 1.91	9.08 ± 1.82	9.18 ± 1.85	0.78
HbA1c2 (%)	8.46 ± 1.52	8.61 ± 1.48	8.42 ± 1.55	8.62 ± 1.46	0.69
FPG1 (mg/dL)	224.5 ± 90.2	235.1 ± 94.5	228.3 ± 91.7	226.9 ± 93.1	0.85
FPG2 (mg/dL)	159.2 ± 30.5	163.4 ± 31.8	158.7 ± 29.9	161.9 ± 32.0	0.77
Urea1 (mg/dL)	33.8 ± 15.1	35.2 ± 16.2	34.1 ± 15.0	34.6 ± 15.8	0.92
Urea2 (mg/dL)	28.7 ± 10.3	29.5 ± 11.1	28.9 ± 10.5	29.3 ± 10.8	0.88
Creatinine1 (mg/dL)	0.76 ± 0.38	0.79 ± 0.41	0.75 ± 0.39	0.77 ± 0.40	0.91
Creatinine2 (mg/dL)	0.71 ± 0.40	0.73 ± 0.43	0.70 ± 0.41	0.72 ± 0.42	0.86
Uric acid1 (mg/dL)	4.89 ± 2.21	5.03 ± 2.35	4.95 ± 2.28	5.01 ± 2.30	0.94
Uric acid2 (mg/dL)	4.02 ± 1.25	4.11 ± 1.28	4.05 ± 1.26	4.09 ± 1.27	0.90

Values are mean ± standard deviation. p-value from Kruskal–Wallis test; no significant differences were observed across groups (p > 0.05 for all comparisons)

ABO blood groups, with the maximum mean age in blood group O (57.5 years) (Table 2). The age difference was not statistically significant among groups (p = 0.62, Kruskal--Wallis test).

3.3 Glycemic control and renal markers: The mean HbA1c level was 9.13 ± 1.83% at baseline, showing poor glycemic control. The mean of fasting plasma glucose was 229.38 ± 92.91 mg/dL, confirming hyperglycemia (Table 3).

3.4 Association of ABO blood groups and biochemical markers: No significant differences in biochemical markers were detected among the ABO blood groups (A, B, AB, and O) at either assessed time point, as shown in Table 5. The Kruskal-Wallis tests produced p-values exceeding 0.05 for all comparisons involving HbA1c, fasting plasma glucose, urea, creatinine, and uric acid across the different blood groups. These findings indicate that, within this sample, ABO blood group does not appear to be linked to variations in glycemic control or renal function.

3.5 Correlation between HbA1c and Biochemical parameters: Although no association was found between ABO blood groups and the variables studied, correlation analysis demonstrated a positive relationship between HbA1c and fasting plasma glucose levels, alongside negative correlations with serum urea, serum uric acid, and serum creatinine. The correlation coefficients and corresponding p-values are detailed in Tables 4A and 4B. Furthermore, analysis of the relationship between age and biochemical parameters showed no significant correlations at either time point, as shown in Table 4C.

4. Discussion

In a cross-sectional study of Iraqi patients diagnosed with COVID-19 and diabetes during the period 2020-2021, we aimed to determine the distribution of ABO blood groups along with their relevance to parameters that determine glycemic control and renal markers in that cohort. Blood groups B and A were identified as the most prevalent in the studied population, followed by groups O and AB. This distribution deviates from the global trend, where blood group O is typically dominant, but aligns with earlier reports concerning Iraqi populations[10]. The elevated frequencies of groups A and B may be influenced by underlying genetic factors or potential selection bias related to diabetes and susceptibility to COVID-19;

however, given the limited sample size, more extensive population-based investigations are required to clarify these observations.

The elevated mean HbA1c (9.13%) indicated that a significant proportion of patients suffered from poor long-term glycemic control. Having high blood sugar and poorly managed diabetes can weaken the immune system's ability to fight off infections. It can also increase inflammation, heightening susceptibility to severe viral infections. Therefore, managing diabetes may help prevent serious viral illness[15]. In diabetic COVID-19 patients, poor glycemic control can exacerbate worse outcomes, such as oxidative stress, endothelial dysfunction, and increased pro-thrombotic tendencies[16]. The cohort exhibited renal-related biochemical changes that indicated specific alterations in kidney components. Chronic hyperglycemia is known to lead to glomerular damage, microvascular injury, and the progression of diabetic nephropathy, highlighting the biological relevance of the relationship between glycemic control and kidney markers. Furthermore, the COVID-19 virus has the potential to worsen kidney issues due to factors such as inflammation, dehydration, low oxygen levels, and direct viral damage[17].

The correlation analysis showed a positive relationship between HbA1c and fasting plasma glucose. This result was expected, as both measurements are indicators of blood sugar levels. Of interest, HbA1c negatively correlated with certain renal markers including urea, creatinine, and uric acid. This may be explained by sample-specific variations, time of laboratory evaluation, pharmacologic influence, or variability in acute versus chronic metabolic state during COVID infection. These findings offer strong rationale for considering clinical context as well as hydration and disease severity when interpreting laboratory biochemical markers in patients with diabetes who contract COVID-19[18,19].

Regarding ABO blood groups, there have been previous publications hypothesizing about potential associations of certain blood groups with susceptibility or severity of COVID-19 disease[19]. While our study did not identify any statistically significant associations between ABO blood groups and the observed biochemical profiles, ABO distribution among our patients provides a baseline for future epidemiological studies to assess the Iraqi diabetic patient with COVID-19. Our data may be used as a reference when attempting to elucidate any effects of blood groups on disease severity, hospitalization, and mortality. Consistent with these findings, the analysis of biochemical parameters according to ABO blood group (Table 5) revealed no significant differences. This observation supports the absence of a direct relationship between ABO blood types and either glycemic control or renal function within this cohort of diabetic patients with COVID-19.

Limitations

There are limitations to our study: First, our cross-sectional study design makes it difficult to establish causality between ABO blood group and biochemical markers of disease progression. Second, Rh-negative blood types were rare (A− and B−), which limited power for subgroup analysis. Third, we did not assess clinical severity outcomes (e.g., ICU admission requirement, oxygen requirement, mortality) of COVID-19 disease, which would help to determine clinical impact of COVID-19 with differing ABO blood types. Lastly, we were unable to account for some important potential confounders that were unavailable (e.g., duration of diabetes, body mass index, hypertension, medication use such as steroids, baseline kidney disease).

5. Conclusion

In this Iraqi cross-sectional study during 2020-2021 about diabetic patients with COVID-19 infection, blood groups B and A were the most common, accounting for 32.2% and 28.7% of patients, respectively. the studied patients had poor glycemic control shown by high HbA1c and fasting plasma glucose levels. There was a significant correlation between HbA1c with fasting glucose and renal-related biochemical markers which indicates metabolic--re-

nal axis connection. There were no distinct relationships found relating ABO blood groups as well as indices of glucose homeostasis neither renal function. To better understand the potential influence of ABO blood types on individuals at elevated risk, especially regarding COVID-19, studies involving larger populations and more detailed clinical outcomes are needed.

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Conflict of Interest

The authors declare no conflict of interest.

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References

1. Getawa S., Bayleyegn B., Aynalem M., Worku Y.B., Adane T. Relationships of ABO and Rhesus blood groups with type 2 diabetes mellitus: a systematic review and meta-analysis. *J. Int. Med. Res*. 50, 1-16, 2022.
2. Cano E.A., Esguerra M.A., Batausa A.M., Baluyut J.R., Cadiz R., Docto H.F., Encabo J.R., Gomez R.M., Sadang M.G. Association between ABO blood groups and type 2 diabetes mellitus: a meta-analysis. *Curr. Diabetes Rev.* 19, e270422204139, 2023.
3. Walle M., Tesfaye A., Getu F. The association of ABO and Rhesus blood groups with the occurrence of type 2 diabetes mellitus: a comparative cross-sectional study. *Medicine.* 102, e34892, 2023.
4. Xie S., Li S., Su S., Zhang E., Gao S., Zhang Y., Liu J., Hu M., Liu R., Yue W., Yin C. Association between ABO Blood Types and the Risk of Gestational Diabetes Mellitus: A Prospective Cohort Study. *Biomed. Environ. Sci*. 38, 678-692, 2025.
5. Yefet E., Bar L., Izhaki I., Iskander R., Massalha M., Younis J.S., Nachum Z. Effects of probiotics on glycemic control and metabolic parameters in gestational diabetes mellitus: systematic review and meta-analysis. *Nutrients.* 15, 1633, 2023.
6. Dutta A., Bhansali A., Rastogi A. Early and intensive glycemic control for diabetic foot ulcer healing: a prospective observational nested cohort study. *Int. J. Lower Extremity Wounds*. 22, 578-587, 2023.
7. Dinavari M.F., Sanaie S., Rasouli K., Faramarzi E., Molani-Gol R. Glycemic control and associated factors among type 2 diabetes mellitus patients: a cross-sectional study of Azar cohort population. *BMC Endocr. Disord.* 23, 273, 2023.
8. Rakhis S.A., AlDuwayhis N.M., Aleid N., AlBarrak A.N., Aloraini A.A. Glycemic control for type 2 diabetes mellitus patients: a systematic review. *Cureus.* 14, e26180, 2022.
9. Arkew M., Asmerom H., Tesfa T., Tsegaye S., Gemechu K., Bete T., Haile K. Red blood cell parameters and their correlation with glycemic control among type 2 diabetic adult patients in Eastern Ethiopia: a comparative cross-sectional study. *Diabetes Metab. Syndr. Obes*. 15, 3499-3507, 2022.
10. Ad'hiah A.H., Abdullah M.H., Alsudani M.Y., Shnawa R.M.S. Association between ABO blood groups and susceptibility to COVID-19: profile of age and gender in Iraqi patients. *Egypt. J. Med. Hum. Genet*. 21, 1-7, 2020.
11. Asad L., Mirza T., Kumar S., Khatoon A. Effect of ABO blood group on the severity and clinico-pathological parameters of COVID-19. *J. Coll. Physicians Surg. Pak*. 31, S1-S5, 2021.
12. Abudouleh E., Owaidah T., Alhamlan F., Al-Qahtani A.A., Al Sarar D., Alkathiri A., Alghannam S., Bagasi A., Alkhulaifi M.M., Al-Qahtani A.A. Association Between ABO Blood Groups and SARS-CoV-2 RNAemia, Spike Protein Mutations, and Thrombotic Events in COVID-19 Patients. *Pathogens*. 14, 758, 2025.
13. Mehta M. Insights into HbA1c: Key Role in Dia-

betes Screening and Monitoring. *J. Diabetes Res. Clin. Pract.* 210, 111987, 2025.
14. Sarı I.K., Çelik M., Gök M., Kara M., Yılmaz S., Aydın M., Demir A., Özkan A., Kaya E., Şahin B. The Effect of Diabetes Mellitus and Glycemic Parameters on COVID-19 Outcomes. *Int. J. Clin. Pract*. 2025, 5566405, 2025.
15. Parv D., Choudhary R., Singh A., Kumar V., Sharma P., Gupta S., Mehta N., Jain R., Agarwal S., Yadav M. Association between ABO blood groups and risk of COVID-19 infection: an umbrella review. *J. Health Allied Sci.* 14, 123-130, 2024.
16. Azim T., Hasan M., Rahman A., Hossain M., Islam K., Chowdhury S., Khan M., Ahmed F., Begum R., Alam S. Impact of COVID-19 on Nephropathy in Diabetes Mellitus Type II Patients: A Systematic Review and Meta-Analysis. *BMC Nephrol.* 25, 45, 2024.
17. Wu B.B., Liu X.Y., Chen Y., Wang J., Zhang L., Li H., Xu M., Zhao Y., Sun Q., Yang J. Association between ABO blood groups and COVID-19 infection, severity and demise: systematic meta-analysis. *Front. Med*. 7, 615, 2020.
18. Guo K., Zhang L., Wang Y., Chen H., Liu J., Zhou F., Yang X., Xu L., Zhao W., Sun Y. Clinical outcomes and predictive modeling in COVID-19 patients with type 2 diabetes mellitus: a multicenter retrospective cohort study. *BMC Infect. Dis.* 25, 123, 2025.
19. Zhao J., Yang Y., Huang H., Li D., Gu D., Lu X., Zhang Z., Liu L., Liu T., Liu Y., et al. Relationship between the ABO Blood Group and COVID-19 susceptibility: a meta-analysis. *Clinical Infectious Diseases,* 73(2), 328–331,2021