

Original Article

The ABO Blood Group System and Plasmodium Infection in Iran: A Comprehensive Study

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Abstract

Background and Purpose: Geographical distribution of ABO blood groups affects by race, ethnicity, migration and some infectious agents, such as Plasmodium species. *P. falciparum* is the major causative agent of death in malaria that can affect ABO blood group distribution in different populations. Therefore, the objective of the current study was to determine the effect of *p. falciparum* on ABO blood group distribution in Iran.

Materials & Methods The present study was conducted on the database of Iranian Blood Transfusion Organization (IBTO) in 30 provinces of the country about ABO and Rh blood groups of the people who referred to health centers from June 2011 to August 2012.

Results: A total number of 2124560 individuals were referred to IBTO in 30 provinces. The highest and lowest rates of O blood group were observed in Sistan & Baluchestan (64.6%) and Lorestan (37.7%), respectively. *P. falciparum* was the most common species of malaria in Sistan & Baluchestan (53215) and the rarest infection agent in Semnan province (20). The results showed statistically significant relationship ($p < 0.05$) between prevalence of *P. falciparum* with O blood group, while this relationship for a blood group was not significant ($p > 0.05$).

Conclusion: Our results revealed a significant relationship between prevalence of *P. falciparum* and geographical distribution of ABO blood. There was also found more susceptibility and risk to malaria infection and cerebral malaria in a blood group compared to other groups. In addition, this was the first comprehensive study on the ABO blood group system and Plasmodium infection in Iran.

Keywords: ABO group; Malaria; Infectious Disease; Plasmodium; Geographical Distribution

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1. Introduction

The ABO blood group system is known as the first human genetic polymorphism which was discovered by Karl Landsteiner in 1901 (1). The system is encoded by multiple alleles at the ABO locus located on chromosome 9. Three main alleles exist at this locus: two co-dominant A and B alleles and one recessive O allele (2). The combination of these alleles formed four major blood groups including A, B, AB, and O, which are carried on the surface of the cells and in secretions (3). The relative proportions and distribution of various ABO groups were influenced by many factors, such as geographical differences, racial, ethnic groups, migration, and genetic characteristics (1).

Moreover, infectious agents, particularly Plasmodium can affect ABO blood group distribution in different populations. Plasmodium infection (malaria) is one of the most significant health problems involving 300 to 500 million people, which causes 2-3 million deaths annually (4).

Plasmodium infection has worldwide distribution, and more than 100 countries are considered as endemic areas for transmission of Plasmodium. Among them, Iran, which is situated in Eastern Mediterranean Region, is considered as a one of malarial endemic areas in southern part of the country (5, 6).

To the best of our knowledge, despite multitude investigations on malaria infection in Iran, there has been no comprehensive study to investigate the effect of Plasmodium infection on the geographical distribution of ABO blood groups in Iran. Therefore, the objective of the present study was to determine the effects of Plasmodium infection on blood group distribution in Iranian population.

2. Materials and methods

This retrospective cross-sectional study was conducted on the database of Iranian Blood Transfusion Organization (IBTO) Center in 30 provinces about ABO and Rh blood group of referred people from June 2011 to August 2012. In addition, data about prevalence and distribution of malaria were collected from health centers of these 30 provinces. Demographic risk factors including sex, age, and residual areas were recorded from each document. Finally, the obtained data were analyzed by SPSS 13.0 Software (SPSS Inc., Chicago, IL, USA). We used t-test and Chi-Square Test (χ^2) for statistical analysis, and the differences were considered to be statistically significant when $P < 0.05$.

3. Results

A total number of 2124560 individuals referred to IBTO in 30 provinces from June 2011 to August 2012. The average age of referred people in case of ABO blood group and patients with malaria were 25 and 27.3 years old, respectively. Regarding the gender of ABO blood group, 65% of them were male and 35% were female, while 59% of male participants and 41% of female participants were infected with Plasmodium. In addition, the distribution of ABO and Rh blood group is shown for each province in Table 1.

NO.	Province	A			O			A/O ratio	<i>P. falciparum</i>
		Total (%)	Rh- (%)	Rh+ (%)	Total (%)	Rh- (%)	Rh+ (%)		
1	East Azerbaijan	55.1	11.2	88.8	44.9	13.3	86.7	1.22	212
2	West Azerbaijan	52.9	10.6	89.4	47.1	11.5	98.5	1.22	295
3	Ardabil	50.7	12.2	87.8	49.3	13.5	86.5	1.02	-
4	Esfahan	57.5	10.1	89.9	42.5	11.6	88.5	1.35	919
5	Ilam	50.7	8.4	91.6	49.3	9.6	90.4	1.03	998
6	Bushehr	35.8	7.2	92.8	64.2	7.7	92.3	0.55	178
7	Tehran	46	10.8	89.2	54	10.8	89.2	0.85	345
8	Chaharmahal & Bakhtiari	42.8	8.9	91.1	57.2	9.2	90.8	0.73	351
9	Khorasan	61	11.5	88.5	39	12.3	87.7	1.59	469
10	Khuzestan	40	8.2	91.8	60	8.5	91.5	0.67	33000
11	Zanjan	48.3	11.4	88.6	51.7	11.6	88.4	0.93	-
12	Semnan	44	10.9	89.1	56	11.1	88.9	0.78	20
13	Sistan & Baluchestan	35.4	8.8	91.2	64.6	9.8	90.2	0.54	53215
14	Fars	41	8.3	91.7	59	8.8	81.2	0.68	8116
15	Qazvin	45.9	13.1	86.9	54.1	12.6	87.4	0.84	-
16	Qom	44.4	10.8	89.2	55.6	11.5	88.5	0.79	-
17	Kordestan	46.8	8.3	91.7	53.2	8.6	91.4	0.87	51
18	Kerman	41.5	9.9	90.1	58.5	10.4	89.6	0.7	26812
19	Kermanshah	48.4	8.8	91.2	51.6	9.5	90.5	0.93	6920
20	Kohgiluyeh & Boyer Ahmad	41	5.9	94.1	59	6.7	93.3	0.69	-
21	Golestan	44.6	10.6	89.4	55.4	11	89	0.8	-
22	Gilan	42.1	11.8	88.2	57.9	12.1	87.9	0.72	106
23	Lorestan	62.3	8.2	91.8	37.7	9.2	90.8	1.65	2354
24	Mazandaran	41	9.7	89.3	59	10	90	0.68	344
25	Markazi	37	7.1	92.9	63	11.2	88.8	0.57	127
26	Hormozgan	51	10.2	89.8	49	9.7	90.3	1.04	33600
27	Hamadan	46.5	9	91	53.5	9.8	90.2	0.86	377
28	Yazd	43.4	13	87	56.6	14.5	85.5	0.76	299

Among the provinces, the highest and lowest rate of O blood group was observed in Sistan & Baluchestan (64.6%) and Lorestan (37.7%), respectively. A blood group was the highest among other blood groups in Lorestan Province (62.3%), whereas this blood group was the lowest in Sistan & Baluchestan (35.4%).

Among the different Plasmodium species, *P. vivax* was the most common species and Plasmodium malaria was the rarest form. Furthermore, *P. falciparum* was the most common species in Sistan & Baluchestan (53215), and the rarest infection agent in Semnan Province (20).

Statistical analysis revealed that there was a significant relationship ($p < 0.05$) between increase of *P. falciparum* and A blood group. However, the increase of *P. falciparum* decreased the rate of O blood group. Besides, in the areas with high prevalence of *P. falciparum*, A blood group had the highest prevalence ($P < 0.05$), whereas in the areas with low incidence of *P. falciparum*, A blood group had the highest percent ($P < 0.05$). There was also no significant relationship between ABO distribution and intensity of malaria parasite infection and other subgroups ($P > 0.05$).

4. Discussion

Genetically ABO blood group system is controlled and proportions of ABO groups significantly differ in different populations and groups. Any national or international study reporting association of ABO groups with a disease should use population frequency of ABO groups as the base for comparison (7).

The ability of forming rosette is reduced in blood group O, therefore individuals in this group have a lower susceptibility to *P. falciparum*. Thus, in the same way, this

study evaluated the effect of influence of *P. falciparum* infection on blood group distribution in a wide population of Iranian. According to the obtained data, *P. vivax* was the most common subgroup of malaria parasites in Iran.

Our findings indicated that the increase of prevalence of *P. falciparum* had a significant effect on the distribution of blood groups in such a way that in areas with a high prevalence of *P. falciparum* and A/O blood group ratio was significantly decreased, and O blood group was significantly high ($P < 0.05$). This finding can be resulted from higher susceptibility of people with a blood to *P. falciparum* infection and resistant of O blood group to this infection. But we found no relationship between type of Rh and *P. falciparum* infection. We also did not find any statistically significant relationship between *P. vivax* infection and ABO and Rh blood group distribution.

The results of a similar study in India by Gupte (2012) on the ABO group distribution information of 8028 malaria cases indicated that 'A' group patients showed a higher susceptibility to malaria infection compared to normal population. The findings also showed the lower incidence of 'O' group patients compared to normal population (8).

In another investigation in India, from the total of 100 patients, 63 cases were positive for *P. falciparum*, 37 cases were positive for *P. vivax* infection and 11 patients had mixed infection. The results of the current study also revealed the advantage of 'O' group over other groups (9). Another study showed the higher incidence of *P. falciparum* infection in individuals of blood group A, B and AB compared with individual of blood group O (10).

The disease occurs due to the proliferation of the intracellular protozoan parasite in liver and invasion to red blood cells. The rosette formation that result from the adherence of infected red blood cells to uninfected and the others infected RBC and platelets leads to microvascular blood flow obstruction and cell death. This adhesion occurs via the rosetting ligand P. falciparum erythrocyte membrane protein (PFEMP1) that is encoded by family of highly parasite genes. Because of a specific structures, this protein can bind to different molecules, such as trisaccharide determinants of A and B blood groups and CD35 on the surface of erythrocytes and CD36 (plateletglycoprotein IV) on the activated platelets, then it binds to vascular endothelial cells through Von Willebrand Factor (VWF) (10-12). Due to low levels of VWF and also absence of the glycosyltransferases enzyme, that is required for production of the A or B antigens, rosetting in blood group O erythrocytes compared with the non-O blood groups is reduced. Blood group 'O' erythrocytes are less prone to constitute rosettes form with P. falciparum parasite-infected RBC due to the decreased cyto-adhesion and rosette formation with the parasites. Therefore, blood group of 'O' individuals unlike the non-O blood groups has a lower susceptibility to severe p. falciparum (10). It seems that death due to the P. falciparum has effect on the distribution of blood groups frequencies in malaria endemic areas and changes it in favor of blood group O.

In conclusion, based on the results of the present study, there was found more susceptibility and risk to malaria infection and cerebral malaria in a blood group compared to other groups. This study showed that there was a statistically

significant positive and negative relationship between prevalence of P. falciparum with O and A blood groups frequency, respectively, but there was no relevance between P. falciparum prevalence and Rh frequency. In addition, this is the first comprehensive study on the ABO blood group system and Plasmodium infection in Iran.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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