Original article

Distribution of red cell antigens according to ABO, Rh and other rare blood group systems in Kurdish ethnicity

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Abstract:

Background: Among more than 30 blood group systems, nine of them namely ABO, Rh, Kell, Kidd, Duffy, MNS, P, Lewis and Lutheran are considered to be clinically significant. The distributions of these blood groups are different between populations across the world. Studies about the frequency of blood groups in Kurdish ethnicity are very limited in the literature.

Objectives: to explore the distribution of red cell antigens and phenotypes of various blood groups among Kurdish population using different systems.

Materials and Methods: five thousand blood donors attending the central blood bank of Sulaymaniyah province were randomly selected and tested for ABO and Rh antigens (D, C, c, E, & e) by using tube method. 500 donors were randomly selected and further analyzed using other blood group systems.

Results: In the ABO system, the most common phenotype was O (37%), followed by A (32.6%), B (22.8%) and AB (7.6%). Among the Rh blood group antigens, e was the most common (95.2%) followed by D (91.3%), C (74.8%), c (69.4%), and E (30.6%) with DCe/DCe(R1R1) and dce/dce(rr) being the most common phenotypes among Rh-D^{+ve} and Rh-D^{-ve} groups, respectively. The most common phenotypes for other blood systems were as follow; Kell(K-k+,94%), Kidd(jk a+b+,44.5%), Duffy(fy a+b+,45%), Lutheran(Lu a-b+,92%), Lewis(Le a-b+,54.5%), P(P1,76%), MNS(M+N+S-s+,40%)

Conclusion: the various red cell antigens recorded by different blood grouping systems in this study was intermediate between the European and Asian countries with some specificity to the Kurds population reflecting the distinct geographical area and preserved ethnic background of the Kurds in the region.

Keywords: ABO, Rhesus (Rh), red cell antigen, Kurdish ethnicity.

Introduction:

The ABO and Rhesus (Rh) blood group systems are among the most clinically important discoveries of the last century in the field of hematology. The ABO blood group system was first discovered by Landsteiner in 1901[(1)]. Later a joint work of the same author with Wiener resulted in the discovery of Rhesus (Rh) blood grouping system in 1940 [(2)]. In these systems, the determination of blood groups is based on certain inherited antigenic substances on the surface of red blood cells (RBCs) [(3)]. These antigens have found to play crucial roles in several clinical areas such as in transfusion medicine, organ transplantation, autoimmune hemolytic anemia (AIHA), fetomaternal blood group incompatibility, paternity identification, and forensic medicine [(4-6)]

According to the International Society of Blood Transfusion (ISBT), there are now more than 270 antigens distributed over 30 distinct blood group systems [1, 7]. Nine of these systems namely ABO, Rh, Kell, Kidd, Duffy, MNS, P, Lewis and Lutheran are considered to be clinically important. Among them, the ABO and Rh systems are the most important systems during blood transfusion due to the fact that their antigens are more immunogenic and active at body temperature [(8)]

The ABO blood group antigens are encoded by one genetic locus, the ABO locus, which has three alternative (allelic) forms A, B, and O, located on the long arm of chromosome 9 [(9)]. The result of this genetic pattern is the four well defined blood groups (A, B, AB, and O). The Rh system is the most polymorphic and the most clinically significant blood group system beside the ABO system. Currently it is composed of 50 antigens associated to genes located on chromosome 1 including RhD, RhC, RhE, Rhc and Rhe which represents the most important Rh antigens [(10,11)]. However, studies have shown that the frequency of allelic distribution of the ABO/Rh blood group varies among different geographical areas and also between populations with different ethnic background across the world. This is probably due to the genetic polymorphism nature of the ABO/Rh genes.

Clinically speaking, blood transfusion is a lifesaving process for some patients, yet it is not free from transfusion-related risks such as transfusion transmissible diseases (TTD) and alloimmunization [(12)] .It is crucial to determine the phenotype of clinically

significant blood group antigens on the donor RBCs especially in situations when alloimmunization is particularly undesirable. Examples of this include young females, pregnant women, and patients who are expected to require repeated blood transfusion in their life such as in patients that have thalassemia, sickle cell anemia, cancer, dialysis, etc.

Racial differences in blood group antigen distribution are common between different populations across the world. Available data in the literature have relatively clarified the genotype/phenotype variation of blood group systems in the European, American and some Asian countries. However, such information in developing countries is still limited. Kurdish population are normal inhabitants of the northern part of Iraq (called Kurdistan or Kurdistan region of Iraq) where only ABO and Rh (D) status of blood donors and recipients are taken into account for compatibility testing. A part of two recent regional studies about the ABO/Rh blood group systems [13,14] information is very limited regarding the extended population blood groups especially using systems other than the ABO/Rh blood groups. In the present study we, for the first time, determined the extended red cell antigens and phenotype frequencies of various clinically significant blood groups amongst regular healthy Kurdish voluntary blood donors in Sulaymaniyah province. This study provides valuable information about the normal distribution of different blood groups among the Kurdish population and it can be used to establish a foundation of donor database for different RBC antigens.

Materials and methods:

Study Design:

This work is a cross-sectional study carried out from 1st of June to 30th of September 2014 in the Central Blood Bank of Sulaymaniyah province/Iraq. The study was conducted after taking approval from blood bank and informed consent from blood donors for their participation in the present study.

Donor Selection:

A total of 5000 healthy regular voluntary blood donors (aged between 18-60 years) were included in this study. All the donors were subjected to red cell antigen typing using ABO/Rh (D) blood group antigen systems. Out of them, 500 donors were randomly selected for further antigen typing using other Rh blood group antigens including C, c, E, and e. In addition, 400 donors were also randomly selected for extended antigen typing using other blood group systems including Kell (k-cellano), Kidd (Jka, Jkb), Duffy (Fya, Fyb), MNSs (M, N, S, s), Lewis (Lea, Leb), Lutheran (Lua, Lub) and P (P1).

Sample collection and methods:

Blood samples were collected in ethylene diamine tetra acetic acid (EDTA) tubes and analyzed freshly for ABO/Rh antigen detection using acryl amide gel technique following the manufacturer's instruction. This system uses ID card "DiaClon ABD-Confirmation for Patients" which contains monoclonal anti-A, B and D within the gel matrix (Bio-Rad Laboratories, DiaMed Switzerland). A small portion (3-5%) of the RBCs suspended in isotonic saline solution was further analyzed by Direct Antiglobulin Test (DAT) according to standard protocols. The DAT negative samples were further typed for extended antigen profiling through antigen-antibody agglutination method using kits supplied by Rapid Labs Limited, England following the manufacturer's guidelines. The ABO and Rh (C, c, E & e) antigen detection were performed by indirect Antiglobulin Technique (IAT), using monoclonal IgG antisera [15]. The tests are interpreted depending on the finding of the agglutination which are graded as 1+ to 4+ positive, or negative which indicating the absence of the of corresponding antigen.

Results:

The results of the ABO system showed that the most common blood group was O (37.0%), followed by A (32.6%), B (22.8%) and AB (7.6%). The results also demonstrated that the majority of donors were positive for Rh (D) antigen (91.26%) while minority (8.74%) were negative based on the Rh blood group system (Table 1). The frequency of the ABO phenotypes associated to the Rh (D) phenotype was as follow: for the Rh (D) positive individuals; the most common blood group was O^{+ve} (33.2%), followed by A^{+ve} (29.8%), B^{+ve} (21.1%), and AB^{+ve} (7.1%). While for the Rh (D) negative individuals the ratio was 3.8%, 2.7%, 1.7%, and 0.5% for O^{-ve}, A^{-ve}, B^{-ve}, and AB^{-ve} groups respectively (Table 1). Furthermore, our results also demonstrated that the e antigen had the highest frequency (95.2%), followed by D, C, c & E antigens (91.26%, 74.8%, 69.4% & 30.6%, respectively) as shown in (Table 1 & 3).

Our phenotypic studies suggest that eight probable phenotypes are possibly found in our population. Among them, the DCe/DCe (R^1R^1), and dce/dce (rr) were the most common phenotypes among Rh (D) positive and Rh (D) negative groups, respectively (Table 3).

The frequency of red cell antigens of Kell, Kidd, Duffy, MNS, Lutheran, Lewis and P blood group systems are shown in (supplementary Table 2) and the phenotype frequencies of these systems are presented in (supplementary Table 3). According to the Kell blood group system K-k+ was the most common phenotype (94.2%) in our donors and no K+k- & K-k- phenotypes were observed in any donors. In the Kidd system, Jk (a+b+) was predominant (44.5%) and no Jk (a-b-) was observed. Jka and Jkb antigens were determined in (77%) and (67.5%) of donors, respectively. The Duffy system showed Fy (a+b) as the most common phenotype (45%). The Duffy null or Fy (a-b-) phenotype was observed in (4%) of donors, while Fya and Fyb antigens were observed in (72%) and (51.5%) of donors, respectively. In the Lutheran blood group system, the most common phenotype was Lu (a-b+) (92%). Lua and Lub antigens were observed in (4.5%) and (95.5%) of donors, respectively, while, null phenotype Lu (a-b-) was determined in (3.5%). The predominant phenotype of the Lewis system was Le (a-b+) (54.5%). Lea and Leb

antigens were observed in (43.5%) and (64.5%) of donors, respectively. Approximately, (76%) of donors were shown to be positive for P1 antigen. Finally, in the MNSs blood group system, (33.5%) of donors were homozygous for M antigen (M+N-), while only 20.5% were homozygous for N antigen (M-N+). Blood groups (M+N+) and (S-s+) were the most common phenotype with the same percentage (46%) and no S-s- phenotype was found. Out of nine possible phenotypes, (M+N+S-s+) was the most common phenotype (40%), whereas (M-N+S+s-) was the least common phenotype (0.5%) observed in the MNS blood group system of the current study (supplementary Table 3).

Discussion:

The knowledge of prevalence of various blood group antigens and phenotype frequencies in the local donor population is important in transfusion services especially in areas of antenatal serology, paternity testing, and selecting compatible blood in problem transfusions [24].

The ABO/Rh blood group system:

It is well established that ABO and Rh genotypes and phenotypes vary widely across races and geographical boundaries. Some variations may even occur in different areas within one small country [16]. Despite the fact that the antigens involved are stable throughout life, the resultant polymorphism remains important in population genetic studies, estimating the availability of compatible blood, evaluating the probability of hemolytic disease in the newborn, resolving disputes in paternity/maternity and for forensic purposes [17].

In this study, we examined the RBC antigens and phenotype frequencies of the ABO and Rh blood groups in local donor population of Sulaymaniyah province (The northern part of Iraq) using different blood group systems. All the donors were males and belong to well-known Kurdish tribes living in the city and surrounding area. Our results indicated that the blood group O was the most frequently encountered phenotype (37.0%) followed closely by the blood group A (32.6%), then B (22.8%), and the lowest one was AB (7.6%). The results also demonstrated that the majority of donors were positive for Rh (D) antigen (91.26%) while minorities (8.74%) were negative. These results are in agreement with the general trend of the ABO blood groups (O > A > B > AB) and Rh (Rh^{+ve} > Rh^{-ve}) recorded for the Kurdish population in

northern Iraq (Erbil and Duhok city) [13,14], Arabian population lives in Iraq and some other neighboring countries [18-21]. However, variation between the frequencies of the blood groups is observed (supplementary Table 4). This variation may due to differences in the geographical area and racial background. Similar results were also observed in populations of other ethnicity such as Caucasian [33], Blacks and Europeans [34]. On the other hand in many Asian populations, there is an increase in the prevalence of group B, e.g. India and Malaysia [22,23]. Our results were not comparable to that reported in the neighboring Turkey [24], and Syria [25], in which higher prevalence of group A was reported (supplementary Table 3). The lowest frequent phenotype of the ABO system linked to the Rh (D) phenotype was AB^{-ve} (0.5%) which is similar to Jaff's observation in Erbil, a neighboring city within the Kurdistan Region of Iraq [13].

Regarding the frequency of Rh antigens (D, C, c, E and e), we found that the e antigen has the highest frequency (95.2%), followed by D (91.3%), C (74.8%), c (69.4%) and the lowest frequent antigen was E (30.6%). This observation is very close to the results of a recent study performed in Duhok city [e (95.6%), D (91.1%), C (75.9%), c (68.1%) and E (25.1%)] and a part from D, the frequency of other Rh antigens was in agreement with observation of Mashaali in Baghdad in which the frequency of e, C, c and E were (94%, 77%, 67% and 32 %, respectively) [14-19]. To our knowledge, these are the only two studies available for comparison in Iraq.

Comparing to the neighboring countries of Iraq, the results of the current study are comparable with studies performed in northeast of Iran [26] and Bahrain (Jenan YT (2012). However, apart from e antigen, the results were markedly different from that reported in other countries such as north Indian [27] (see Table 4).

A significant difference was observed in the frequency of C, E c, and e antigens when donors were categorized as D^{+ve} and D^{-ve}. In D^{+ve} donors the distribution of C and E antigens was (81.7% and 34.2%, respectively) while in D^{-ve} donors was (17% and 0%) ($P < 0.05$), suggesting that C and E antigens are more prevalent on D^{+ve} red cells. In contrast, the c and e antigens were detected in almost all D^{-ve} donors (100%) as compared to the less frequency occurrence in D^{+ve} donors (65.8% and 94.6% for c and e respectively) ($P < 0.05$). These results are in accordance with a study in north Indian

population in which the frequency of C and E antigens in D^{+ve} donors were massively higher than their presence among D^{-ve} donors, while the prevalence of c and e was in contrast [27]. Moreover, these results are further supported by our observation that DCe/DCe (R^1R^1) was the most common phenotype (34%), followed by DCe/dce (R^1r) (29.6%) and DCe/DcE (R^1R^2), and (18.3%) in our D^{+ve} donors, while the dce/dce (rr) found to be the most common phenotype (83%) in D^{-ve} donors (see Table 4). This genotype pattern shows strong similarities to that reported in northeast Iran and some similarities to north India and Caucasians population. However, the pattern was far different from what reported in Blacks as shown in (Table 4).

Other blood group systems:

The Kell Blood Group System:

The K antigen is very immunogenic (second to the D antigen) in stimulating antibody production. Anti-K is an important antibody as it is nearly always immune, IgG, and complement-binding. It causes severe HTRs and HDFN [28]. Its frequency in this study was low (5.8%), which is similar to that of Thakral et al. study in north India (5.56%) [27], and it occurs between the frequencies reported by Keramati et al. in northeast of Iran [26] and Whites (8%, and 9%, respectively), but higher than Blacks (2%) [29]. In contrast, frequency of k (Cellano) antigen was detected in almost (100%) in our donor population, which is similar to the results reported in north Indian 100% (Thakral et al. 2010), and black populations 100% [29], but differ from the results obtained from Whites and northeast-Iran who showed negative results for k (Cellano) antigen by 0.2%, 2.3% respectively. This implies that while Whites and northeast Iranian population might occasionally develop anti-k (Cellano), the likelihood of finding this alloantibody in our population is negligible (Table 5).

Regarding the distribution of Kell phenotypes, the most common phenotype was found to be K-k+ (94.2%), followed by K+k+ (5.8%). None of the donor was found to be K homozygous (K+k-) or (K-k-). These results are similar to that reported in north Indian population recorded by two independent studies [27,30]. Again our results were found to be intermediate between Whites/northeast of Iran from one side [26] and the Black population from another side [29] (Table 5).

The Kidd Blood Group System:

The frequencies of Kidd blood group system antigens (Jk^a = 77%, Jk^b = 67.5%) observed in this study was similar to those in northeast of Iran [26], and comparable to that of Whites (Beadling & Cooling, 2007), and north-Indian population [27], while there was a remarkable difference with the Black population (Jk^a = 92%, Jk^b = 49%) [29] (Table 5).

The most common Kidd phenotype was Jk (a+b+) (44.5%), which is similar to those in northeast of Iran [26], and comparable to north India [27] and Whites [29] (49.21 % and 49%, respectively), while much higher than what recorded for Blacks (34%). The Jk (a+b-) is found to be the most common phenotype among the Blacks (57%) [29]. No Jk (a-b-) phenotype was detected in any donor, which is also very rare in White and Black people, except for Polynesians (< 1%) [29] (Table 5).

The Duffy Blood Group System:

The frequencies of the Duffy blood group system antigens were (Fy^a =70%, Fy^b=57.5%). The Fy^a antigen frequency is very close to that reported in northeast of Iran (73.8%) [26], and it is intermediate between results reported in north Indian population [27], and Whites [29], which are 86.75%, 66%, respectively. While the frequency of Fy^b antigen is much closer to that reported by Thakral *et al.* (56.15%), and it is in between Keramati *et al.* study and Whites (49.2%, 83%, respectively). However, again our results showed much higher percentage of Duffy antigen than the Blacks (Fy^a = 10%, Fy^b = 23%) [29] (Table 6).

In this system, Fy (a+b-) was the most common phenotype in our study was (38.5%), which is comparable to the results reported in north-India [27] and northeast of Iran [26], which are (43.9%, 47.4%, respectively). However, it is much higher than Whites (17%) and Blacks (9%) population [29]. The most common reported phenotype in Whites is Fy (a+b+) 49%, and in Blacks is Fy (a-b-) (68%) [29].

Duffy antigen is postulated to be the receptor for entry of the *plasmodium vivax* on the red cells [31,32]. This probably explains high prevalence of Duffy null phenotype Fy (a-b-) in the endemic area of malaria such as among the black people (68%) [29,33,34]. The frequency of Duffy null phenotype Fy (a-b-) in our study was (4%), which is very close to that reported by Keramati *et al.* in northeast of Iran (3.4%) [26]. While it is very rare in Whites (Beadling & Cooling, 2007)

and (0%) in north Indian population [27] (Table 6). This higher rate of null phenotype frequency in our donors might be related to the existence of endemic areas of malaria in the Kurdistan Region of Iraq in the past.

The MNSs Blood Group System:

The frequencies of the MNSs blood group system antigens M, N, S and s in our study were 79.5%, 66.5%, 54%, and 88.5%, respectively. These results are similar to the results reported in north Indian population (75.4%, 61.5%, 56.5%, and 87.4% for M, N, S and s respectively) [27]. The results are also comparable with the observation of Keramati *et al.* in northeast of Iran (87%, 56.7%, 56.7%, and 84.5%, respectively) [26], and Whites (78%, 72%, 55%, and 89%, respectively), while they are different with what recorded for Blacks, particularly for S and s antigen frequencies [29] (Table 6).

Regarding the phenotype frequency, M+N+ and S-s+ were the most common phenotypes observed in the MNS blood group system in our study which were nearly equal (46%) to each other. These results are comparable to that of Keramati *et al.* study who reported that M+N+ and S-s+ are the most common phenotypes (43.7% and 43.3%, respectively) [26]. The results are also comparable to that reported in White and Black populations[29], while in Thakral *et al.* study the most common phenotype was M+N- and S+s+ (Table 6).

Out of nine possible phenotypes found in our study, M+N+S-s+ (40%) was the most common phenotype; whereas, M-N+S+s- (0.5%) was the less common phenotype observed in the MNS blood group system. The frequency of M+N+S-s+ in this study, is comparable to the results reported by Agarwal *et al.* in India (28.8%) (Agarwal *et al.* 2013), as well as in Europeans (22.6%) and African-Americans (33.4%) [35,36], while in Thakral study in north Indian population the most common phenotype was M+N+S+s+ (19.6%) (Table E).

Conclusions:

The knowledge of these antigen and phenotype frequencies is crucial in the clinical field. Based on this information, one can predict the common alloantibodies that could be happened in pregnant women and patients receiving blood transfusions. For instance, E antigen frequency in our donor population was the lowest (30.6%), followed by c antigen (69.4%) in ascending order of frequency. Thus, it can be assumed that the most common alloantibodies in Rh blood group system among pregnant women and in patients receiving blood transfusion would

be anti-E and then anti-c. Another advantage of knowing antigen and phenotype frequency is that it helps in selection of antigen negative blood units for patients with pre-formed alloantibodies. For example, if a patient in our population has alloantibody against C and needs two units of blood, a minimum of 8-10 units of ABO and Rh (D) matched blood units will need to be tested for C antigen to find two units of antigen negative blood (since C antigen negative donors form about 25% of all our donor's population). This notion is also applied to the less common blood group systems included in this study.

Over all, the various red cell antigens recorded by different blood grouping systems in this study was intermediate between the European and Asian countries with some specificity to the Kurds population reflecting the distinct geographical area and preserved ethnic background of the Kurds in the region.

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Authorship contributions:

HAG have designed the research and shared in writing the article, SSA did all laboratory work and shared in writing the article, NK reviewed and shared in writing editing, and designing the article. BAM reviewed the article, redesigned the paper, and did major editing of all parts of the writing, also submitted the paper.

Conflict of interest:

All authors declares that there is no conflict of interest.

Tables

Table 1: Distribution of ABO and Rhesus (Rh) blood groups both individually (upper panel) and in combination (lower panel). Upper panel, the total number of donors and the percentage of each group is given. The most common ABO blood group was O (37.0%), followed by A (32.6%), B (22.8%) and AB (7.6%). Most of the donors were positive for Rh (D) antigen (91.26%) and minority (8.74%) were negative. **Lower panel,** the number and percentage of donors for each blood group is given. The total number of donors also provided. In both Rh^{+ve} (left) and Rh^{-ve} (right) groups the most common ABO blood group was O, followed by A, B, and AB as indicated regardless of the presence/absence of Rh antigen. N = 5000.

Blood groups	Number of donors	Percentage (%)
ABO blood groups		
O	1850	37
A	1630	32.6
B	1140	22.8
AB	390	7.8
Rh (D) blood groups		
Rh (D) positive (Rh^{+ve})	4550	91.3
Rh (D) negative (Rh^{-ve})	435	8.7

ABO/Rh (D) positive (Rh^{+ve})			**ABO/Rh (D) negative (Rh^{-ve})**		
Blood groups	**Number & (%) of donors**		**Blood groups**	**Number & (%) of donors**	**Total number of donors**
O^+	1662 (33.2)		O^-	190 (3.8)	1852 (37.0)
A^+	1491 (29.8)		A^-	137 (2.7)	1628 (32.6)
B^+	1055 (21.1)		B^-	84 (1.7)	1139 (22.8)
AB^+	355 (7.1)		AB^-	26 (0.5)	381 (7.6)
Total	**4563 (91.3)**			**437 (8.7)**	**5000 (100%)**

Tables

Table 2: Distribution of other Rh antigens (C, c, E, and e) and phenotypes. A) The number and percentage of donors for each blood-group antigen is given. The most common antigen was e (95.2) followed by C (74.8), c (69.4), and E (30.6). **B)** The Rh phenotype in Rh (D) positive (Rh^{+ve}) donors. **C)** The Rh phenotype in Rh (D) negative (Rh^{-ve}) donors. The most common Rh phenotype was R1R1 (DCe/DCe) (34%) in Rh^{+ve} donors, while rr (dce/dce) was the most common phenotype (83%) among Rh^{-ve} donors. N = 500.

	Number of positive donors	Percentage of positive donors
A) Rh Antigens		
C	374	74.8
E	153	30.6
c	347	69.4
e	476	95.2
B) Phenotypes in Rh (D) positive (Rh^{+ve}) donors		
R^1R^1 (DCe/DCe)	152	34
R^1r (DCe/dce)	132	29.6
R^1R^2 (DCe/DcE)	82	18.3
R^2r (DcE/dce)	47	10.5
R^2R^2 (DcE/DcE)	24	5.4
R^0r (Dce/dce)	10	2.2
C) Phenotypes in Rh (D) negative (Rh^{-ve}) donors		
rr (dce/dce)	44	83
r′r (dCe/dce)	9	17

Tables

Table 3: Phenotype frequencies in systems other than ABO/Rh. Results of Kell, Kidd, Duffy, Lutheran, Lewis, P, and MNSs blood group systems are presented in percentage as indicated, N = 400.

Blood group system	Phenotype	Donors (%)
Kell system	K-k+	94.2
	K+k+	5.8
Kidd System	Jk (a+b+)	44.5
	Jk (a+b-)	32.5
	Jk (a-b+)	23
Duffy System	Fy (a+b-)	38.5
	Fy (a+b+)	31.5
	Fy (a-b+)	26
	Fy (a-b-)	4
Lutheran system	Lu (a-b+)	92
	Lu (a+b+)	3.5
	Lu (a-b-)	3.5
	Lu (a+b-)	1.0
Lewis system	Le (a-b+)	54.5
	Le (a+b-)	33.5
	Le(a+b+)	10
	Le (a-b-)	2
P system	P_1	76
MNS System	M+N+	46
	M+N-	33.5
	M-N+	20.5
	S-s+	46
	S+s+	42.5
	S+s-	11.5
	M+N-S+s-	5.5
	M+N-S+s+	19
	M+N-S-s+	18
	M+N+S+s-	22.5
	M+N+S+s+	17.5
	M+N+S-s+	40
	M-N+S+s-	0.5
	M-N+S+s+	6
	M-N+S-s+	14.5

Tables

Table 4: Frequencies of Rh phenotypes. The observed Rh phenotype of the present study compared to the published data of other countries as indicated.

Phenotypes	Present study (%)	North-India[1] (%)	Northeast Iran[2] (%)	Caucasian[3] (%)	Black[3] (%)
DCe/DCe (R^1R^1)	30.4	35.2	25	18.5	2.0
DCe/dce (R^1r)	26.4	30.7	31.8	34.9	21.0
DCe/DcE (R^1R^2)	16.4	8.1	16.5	13.3	4.0
DcE/dce (R^2r)	9.4	5.9	9.6	11.8	18.6
DcE/DcE (R^2R^2)	4.8	0.7	1.7	2.3	0.2
Dce/dce (R^0r)	2	2.2	4.2	2.1	45.8
dce/dce (rr)	8.8	0.3	8.3	15.1	6.8
dCe/dce (r′r)	1.8	2.5	1.3	0.8	Rare

[1]: Sarkar *et al.* 2013 **[2]:** Keramati *et al.* 2011 **[3]:** Reid & Lomas-Frances, 2004

Tables

Table 5: Phenotype frequencies of the Kell and Kidd blood group systems. Antigen frequencies (%) of Kell and Kidd blood group systems are compared with other published results as indicated. The phenotype frequencies (%) of the Kidd blood group system was also compared.

People groups	**Kell (K) (%)**	**Cellano (k) (%)**	**K-k+ (%)**	**K+k+ (%)**	**K+k- (%)**	**K-k- (%)**	**References**
Sulaymaniyah-Iraq	5.8	100	94.2	5.8	0.0	0.0	Present study
North-India	5.56	100	94.3	5.7	0.0	0.0	Thakral *et al*. 2010
North-India		97.7	96.0	4.0	0.0	0.0	Nanu &Thapliyal, 1997
Northeast-Iran	8.0	99.8	92.0	5.7	2.3	0.0	Keramati *et al*. 2011
Whites	9.0	100	91.0	8.8	0.2	0.0	Beadling & Cooling, 2007
Blacks	2.0		98.0	2.0	Rare	0.0	Beadling & Cooling, 2007
People groups	**Jk^a (%)**	**Jk^b (%)**	**Jk (a+b+) (%)**	**Jk (a+b) (%)**	**Jk (a-b+) (%)**	**Jk (a-b-) (%)**	**References**
Sulaymaniyah-Iraq	77.0	67.5	44.5	32.5	23	0.0	Present study
Northeast-Iran	79.1	65.1	44.4	34.7	20.7	0.2	Keramati *et al*. 2011
North-India	82.6	66.6	49.2	33.4	17.3	0.0	Thakral *et al*. 2010
Whites	77	74	49	28.0	23.0	Very rare	Beadling & Cooling, 2007
Blacks	92	49	34.0	57	9.0	Very rare	Beadling & Cooling, 2007

Tables

Table 6. Antigen and phenotype frequencies of Duffy and MNSs blood group systems. Antigen and phenotype frequencies (%) of Duffy and MNSs blood group systems in this study compared with other published results as indicated.

People groups	Fy^a (%)	Fy^b (%)	Fy (a+b-) (%)	Fy (a+b+) (%)	Fy (a-b+) (%)	Fy (a-b-) (%)	References
Sulaymaniyah-Iraq	70	57.5	38.5	31.5	26	4.0	Present study
Northeast-Iran	73.8	49.2	47.4	26.4	22.8	3.4	Keramai *et al*. 2011
North-India	86.7	56.1	43.8	42.9	13.3	0.0	Thakral *et al*. 2010
Whites	66	83	17.0	49.0	34.0	Very rare	Beadling & Cooling, 2007
Blacks	10	23	9.0	1.0	22.0	68.0	Beadling & Cooling, 2007

People groups	M (%)	N (%)	S (%)	M+N+ %	M+N - %	M-N+ %	S-s+ %	S+s+ %	S+s- %	s (%)	References
Sulaymaniyah-Iraq	79.5	66.5	54	46	33.5	20.5	46	42.5	11.5	88.5	Present study
North-India	75.4	61.5	56.5	43.7	43.3	13	43.3	41.2	15.5	87.4	Thakral *et al*. 2010
Northeast-Iran	87	56.7	56.7	36.9	38.5	24.6	43.5	43.8	12.6	84.5	Keramati *et al*. 2011
Whites	78	72	55	50	28	22	45	44	11	89	Beadling & Cooling, 2007
Blacks	74	75	31	44	26	30	69	28	3	93	Beadling & Cooling, 2007

Supplementary Data

Supplementary data:

Supplementary Table 2: Antigen frequencies of the Rh (D) blood groups. Results of the Rh system of the present study compared to other parts of Iraq, neighboring countries and some other populations as indicated.

People groups	Rh (D) +ve %	Rh (D) – ve %	References
Sulaymaniyah-Iraq	91.3	8.7	Present study
Erbil-Iraq	91.7	8.3	Jaff, 2010
Babylon-Iraq	90.1	9.9	Salih, 2009
Saudi Arabia	91.2	8.9	Al-Himaidi & Umar, 2002
Bahrain	91.1	8.9	Jenan, 2012
Arians (Pakistan)	91.7	8.3	Ali *et al*. 2005
Kuwait	92.5	7.5	Al-Bustan *et al.* 2002
Iran	90.2	9.8	Keramati *et al*. 2011
India	93.4	6.6	Thakral *et al*. 2010
Baghdad-Iraq	80	20	Mashaali, 2014
Blacks	92	8	Beadling & Cooling, 2007; Barclay, 2001
Whites	85	15	Beadling & Cooling, 2007; Barclay, 2001
Asians	99	1	Reid & Lomas-Frances, 1997

Supplementary Data

Supplementary Table 3: Frequency of red cell antigens in systems other than ABO/Rh. Results of Kell, Kidd, Duffy, MNSs, Lutheran, Lewis and P blood group systems are presented both in absolute numbers and percentage as indicated, N = 400.

Antigens	Number	Percentage (%)
Kell		
K	29/500	5.8
k	400/400	100
Kidd		
Jk^a	308/400	77
Jk^b	270/400	67.5
Duffy		
Fy^a	280/400	70
Fy^b	230/400	57.5
MNSs		
M	318/400	79.5
N	266/400	66.5
S	216/400	54
s	354/400	88.5
Lutheran		
Lu^a	18/400	4.5
Lu^b	382/400	95.5
Lewis		
Le^a	174/400	43.5
Le^b	258/400	64.5
P		
P_1	304/400	76

Supplementary Data

Supplementary Table 3: Antigen frequencies of the ABO blood groups. Results of the ABO system of the present study compared to other parts of Iraq, neighbour countries, and some other populations as indicated.

People groups	O%	A%	B%	AB%	References
Sulaymaniyah-Iraq	37	32	23	8	present study
Erbil-Iraq	37	32	24	7	Jaff, 2010
Babylon-Iraq	36	28	28	8	Salih, 2009
Baghdad-Iraq	39	26	24	11	Mashaali, 2014
Iran	35	33	23	9	Boskabady *et al.* 2005
Iran	34	30	28	8	Keramati *et al.* 2011
Kuwait	44	27	24	5	Al-Bustan *et al.* 2002
Saudi Arabia	51	26	19	4	Sarhan *et al.* 2009
Jordan	37	38	18	7	Hanania *et al.* 2007
Caucasian	47	41	9	3	Guyton & Hal, 2005
African blacks (e.g. Nigeria)	53	24	20	3	Enosolease & Bazuaye, 2008
European	43	40	12	5	Mollison *et al.* 1997
Asians (e.g. India)	39	23	33	5	Ali *et al.* 2005
Asian (e.g. North India)	32	22	37	9	Agrawal *et al.* 2013

Supplementary Data

Supplementary Table 4: Antigen frequencies of extended Rh blood groups (e, C, c, E). Results of the extended Rh blood group system of this study compared to the published data of other parts of Iraq and some other countries as indicated.

People groups	e %	C%	c %	E%	References
Sulaymaniyah-Iraq	95.2	74.8	69.4	30.6	Present study
Baghdad-Iraq	94	77	67	32	Mashaali, 2014
Northeast-Iran	97.9	75.9	73.9	29.5	Keramati *et al*. 2011
Bahrain	97.3	73.2	71	21	Jenan, 2012
North-India	98.1	90.2	49.5	18.9	Thakral *et al*. 2010

Supplementary Table 5: phenotype frequencies of MNSs blood group system compared to other published data as indicated.

Phenotype	Present study (%)	•India (%)	*European (%)	*African American (%)
M+N+S-s+	40	28.7	22.6	33.4
M+N+S+s+	17.5	20.9	22.4	13
M+N+S+s-	22.5	5.12	3.9	2.2
M+N-S-s+	18	13.8	10.1	15.5
M+N-S+s+	19	15	14	7
M+N-S+s-	5.5	7.1	5.7	2.1
M-N+S-s+	14.5	5.1	15.6	19.2
M-N+S+s+	6	3.1	5.4	4.5
M-N+S+s-	0.5	1.2	0.3	1.6

•(Agarwal *et al*. 2013) * Lal *et al*. 2000; Cleghorn, 1960.

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توزيع مستضدات الخلايا الحمراء وفقا لABO، Rhوغيرها من أنظمة فصائل الدم النادرة لدى قومية الكورد العراقيين

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الملخص:

الخلفية: من بين أكثر من 30 نظام لفصائل الدم، تسعة منهم وهما ABO، Rh، Kell، Kidd، Duffy، MNS، Lewis،P وLutheran تعتبر هامة سريريا. توزيعات هذه فصائل الدم تختلف بين السكان في جميع أنحاء العالم. دراسات حول وتيرة فصائل الدم في العرق الكردي محدودة للغاية في المراجع الطبية.

الأهداف: لاستكشاف توزيع مستضدات الخلايا الحمراء والظواهر من فصائل الدم المختلفة بين السكان الأكراد باستخدام أنظمة مختلفة.

المواد والطرق : تم اختيار خمسة آلاف من المتبرعين بالدم الذين حضروا بنك الدم المركزي في محافظة السليمانية عشوائيا واختبارها لABO وRh ومولدات المضادات (D، C، C، E، وه) باستخدام طريقة الأنبوب. وقد تم اختيار 500 عينة من المتبرعين بشكل عشوائي وكذلك تحليلها باستخدام أنظمة فصيلة الدم الأخرى.

النتائج: في نظام ABO، كان النمط الظاهري الأكثر شيوعاهو O (37)٪، تليها A (32.6٪) ، و22.8٪ B() و AB (7.6٪(. بين المستضدات فصيلة الدم Rh، كان e الأكثر شيوعا (95.2٪)، يليه D (91.3٪)، C ٪ (74.8)، c (69.4٪)، و30.6٪ E() مع (R1R1 DCe / DCe) و dce / dce (rr) هي الظواهر الأكثر شيوعا بين RhDالايجابي والسلبي على التوالي. وكانت الظواهر الأكثر شيوعا لأنظمة الدم الأخرى على النحو التالي:

Kell (K-k+,94%), Kidd (jk a+b+,44.5%), Duffy (fy a+b+,45%), Lutheran (Lu a-b+,92%), Lewis (Le a-b+,54.5%), P (P1,76%), MNS (M+N+S-s+,40%)

الخلاصة: مختلف مستضدات الخلايا الحمراء التي سجلتها أنظمة فصيلة الدم مختلفة في هذه الدراسة كان وسطا بين الدول الأوروبية والآسيوية مع بعض الخصوصية للسكان الأكراد يعكس منطقة جغرافية متميزة والخلفية العرقية المحفاظ عليها.

كلمات البحث : الأكراد , ABO ، مستضد الخلايا الحمراء ,Rh