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The phenotypes and alleles frequencies of ABO blood groups in Western Uganda

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Abstract

ABO blood group system is one of the clinically significant blood classification systems that vary across populations. Knowledge of distribution of the ABO blood system can help us to predict herd immunity and transmissibility of a disease in a population. In Uganda, little was known about this system and no research had been carried out to elaborate on the distribution of the A, B, AB and O blood types. Therefore, a cross-sectional study was conducted among people ≥12 years attending Buhinga hospital in Western Uganda from April to June 2019 to determine the phenotypes and alleles frequencies of the A, B, AB and O blood groups. Participants were recruited by simple random sampling technique and demographic data was obtained. 379 venous blood samples were collected and tested for ABO sero-types. Phenotypic data was analyzed using descriptive statistics, chi-square test of association and Hardy-Weinberg law of computation. Frequencies of ABO phenotypes were in the following order; O (39.8%)>, A (39.6%) >, B (12.4%)> AB (8.2%). There was no significant difference in the A, B, AB and O phenotype frequencies between males and females (p-value= 0.91). Based on Hardy-Weinberg Law, frequencies of the A, B, O alleles were; 0.63 for the O allele, 0.27 allele for the A allele and 0.14 for the B allele. Predominance of blood group O is more likely to influence population immunity.

Keywords: ABO blood system; Frequency; Immunity; Phenotype; Allele

1. Introduction

ABO blood group system is of clinical importance in disease pathogenesis and human immunity. Humans have ABO antigens which are found on red blood cells, platelets, leukocytes, plasma proteins, certain tissues and various cell surface enzymes [1] and also exist in soluble form in body secretions such as breast milk, seminal fluid, saliva, sweat, gastric secretions, urine and amniotic fluid [2]. Each of these antigens is an end product of a single gene so genetic changes like insertions, deletions, inversions, alternative slicing or single nucleotide polymorphisms lead to antigenic differences. These changes can also give rise to new antigens or even complete loss of expression [3]. The primary structure of these antigens is either a glycolipid or a glycoprotein, with an oligosaccharide "precursor" sequence and one or more specific sugar molecules attached to it in specific locations [1]. In 1959, ABO, Hh, Sese, and Lele genes were discovered and are responsible for the inheritance patterns of A, B, H, Le^a and Le^b antigens. These antigens are produced by enzymes expressed by these four major genes (ABO, Hh, Sese, and Lele) and are the basis of ABO blood phenotypes [4]. The ABO histo-blood group consists of two antigens (A and B) and four blood types (A, B, AB and O). The A and B antigens are a product of the ABO gene and autosomal codominant. The group O phenotype is an autosomal-recessive phenotype due to homozygous inheritance of two null ABO alleles. These group O individuals express the H antigen, the

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biosynthetic precursor to A and B antigens. The relative distribution of ABO types can vary among different ethnic population, although group O tends to be the most common. Epithelial cells can also express ABH and Lewis antigens on their surfaces that are used by bacteria, parasites and viruses as attachment receptors. This makes individuals susceptible to pathogens depending on their antigenic profile [5]. Some pathogens have antigens similar to the blood group antigens of their hosts, a phenomenon called molecular mimicry and microbes use it as a defense mechanism against their hosts' immune system [5]. Most gram negative bacteria such as Escherichia coli have chemical substances on their surfaces that resemble A and B blood group antigens. Vitro experiments have shown that Anti-B antibodies destroy Escherichia coli [6]. This means that Anti-A and anti-B antibodies may play a role in destroying gram negative organisms in vivo. According to Garratty [6], Individuals of Blood groups O and B have increased incidences of TB while those of blood groups A and AB are associated with increased incidences of small pox. In another contrary study by Rao et. al., (2012) [7], blood group B and AB individuals have been found to have higher TB incidence compared to blood group A and O people. Since the ABO blood system is genetical and is found virtually in all human beings, we believe it plays important roles in influencing population immunity (herd immunity) and transmission of diseases. According to Mourant et, al. 1976, Roychoudhuri and Nei, 1988 [8, 9], individuals consist of different genome structures with alleles which give rise to phenotypes that vary from one population to another. In Uganda, little was known about ABO blood system of the population and no research had been carried out to elaborate on the distribution of blood types. This gave us a reason to determine the phenotypes and alleles frequencies of ABO blood groups in a population of patients attending Buhinga hospital in Western Uganda. The study outcome can be used to predict herd immunity and transmissibility of diseases in a population. The hospital was chosen as a study site because it is a regional referral set up that receives patients from over fifteen districts. Hence, it provided satisfactory ground for unbiased selection of the study participants.

2. Material and methods

2.1. Study design and population set up

A cross-sectional study was designed to determine the phenotype and allele frequencies of ABO blood groups in a patient population ≥ 12 years who were attending outpatient department Buhinga hospital, Kabarole district. From April to June 2019, a total of 379 respondents were randomly recruited into the study. Both demographic information and specimens were obtained from the participants and analyzed.

2.2. Methods and analyses

From each participant, 4 mls of venous blood sample was aseptically collected in the vacutainer blood collection tube with EDTA. Tubes were inverted for 8 to 10 times to mix well with the anticoagulant ready for blood group serology. Thereafter, ABO phenotypes and allele frequencies were estimated.

2.2.1. ABO Blood group serology

Blood samples were centrifuged at 1000 to 1500 rpm for 10 min. Erythrocytes were separated for the determination of blood type. ABO blood group was determined from each sample by the standard forward cell agglutination using anti-A and Anti-B antibodies supplied by Immucor Inc., Norcross, GA, USA.

2.2.2. Estimation of the ABO phenotypes and alleles frequencies

The phenotypes frequencies for the ABO blood groups among the patient population were computed from the sero-typed blood samples obtained from the participants at Buhinga hospital. The alleles frequencies p, q and r were calculated according to Hardy-Weinberg Law $\{p^2\ (AA) + 2pr\ (AO) + q^2\ (BB) + 2qr\ (BO) + 2pq\ (AB) + r^2\ (OO)\}$.

2.3. Statistical analysis

Demographic and phenotypic data were analyzed with descriptive statistics. Test of association was based on chi-square test at 5% level of significance, which compared the proportions of the outcome of A, B, AB and O phenotype frequencies across gender. Alleles computational data was obtained using Hardy-Weinberg Law.

3. Results

Out of 379 participants recruited in the study, 205 (54%) were males while 174 (46%) were females. Majority of the participants (208/ 54.9%) were under age bracket; 30-39 years, followed by 68 (17.9%), and 65 (17.2%) participants under age brackets; 20-29 years and ≥40 years respectively. The least number of respondents (38/ 10%), were under

age group of 10-19 years. 19.3 % (73 of 379) of the participants presented with clinical symptoms suggestive of possible underlying health conditions. Of these 73 clinically symptomatic participants, 31 (8.2%) had noticeable weight loss, 23 (6.1%) had night sweats, 11 (2.9%) had cough while 8 (2.1%) had persistent fevers.

3.1. Frequencies of ABO Blood Groups

The frequencies of ABO phenotypes in the population studded were as follows; O: 151 (39.8%), A: 150 (39.6%), B: 47 (12.4%) and AB: 31 (8.2%) *(Table1)*. The distribution of blood antigens by gender was also analyzed; B and AB blood types were common in males (13.2% and 8.8% respectively) than females (11.5% and 7.5% respectively). Meanwhile, O and A were most prevalent in women (40.2% and 40.8% respectively) than men (39.5% and 38.5% respectively). The ABO gene locus is controlled by three different alleles A, B and O. The frequencies of the A, B and O alleles were calculated according to the Hardy-Weinberg Law of equilibrium based on data present in *(Table 1).* According to Hardy-Weinberg Law the population should consist of: $\{p^2$ (AA) + 2pr (AO) + q^2 (BB) + 2qr (BO) + 2pq (AB) + r^2 (OO)$\}$. Based on this formula, the alleles frequencies of the ABO blood groups in the population was as follows: the frequency of the O allele (r) = 0.63 the frequency of the A allele (p) = 0.27 and the frequency of the B allele (q) = 0.14.

Table 1 Phenotypes, genotypes, sample phenotypic numbers, genotypic frequencies and phenotypic frequencies/ percentages of 379 participants

Gender	Phenotypes	Genotypes	Genotypic frequencies	Phenotypic numbers	Phenotypic frequencies (percentages)
Males	A	AA and AO	p^2+ 2Pr	79	0.385 (38.5%)
	B	BB and BO	q^2+ 2qr	27	0.132 (13.2%)
	AB	AB	2pr	18	0.088 (8.8%)
	O	OO	r^2	81	0.395 (39.5%)
	Sub Total	-	$(p+ q+ r)^2$	205	1.00 (100%)
Female	A	AA and AO	p^2+ 2Pr	71	0.408 (40.8%)
	B	BB and BO	q^2+ 2qr	20	0.115 (11.5%)
	AB	AB	2pr	13	0.075 (7.5%)
	O	OO	r^2	70	0.402 (40.2%)
	Sub Total	-	$(p+ q+ r)^2$	174	1.00 (100%)
All	A	AA and AO	p^2+ 2Pr	150	0.396 (39.6%)
	B	BB and BO	q^2+ 2qr	47	0.124 (12.4%)
	AB	AB	2pr	31	0.082 (8.2%)
	O	OO	r^2	151	0.398 (39.8%)
	Total	-	$(p+ q+ r)^2$	379	1.00 (100%)

4. Discussion

There is more than one system of blood classification, but the commonest is the ABO system. The ABO blood system consists of two antigens (A and B), four blood phenotypes (A, B, AB and O) and three alleles (O, A and B). The A and B antigens are found on most of the human cell surfaces [4], some tissues such as lung tissues [10], intestinal mucosa [11], nervous receptors and vascular endothelium [12]. However, distribution of the ABO alleles and phenotypes varies between different populations [8]. In this study, the trend of O> A > B> AB blood phenotypes frequencies correlated with the order of O>A>B alleles frequencies. According to Hardy-Weinberg Law, the O, A and B alleles contained genotypes whose estimated order frequencies were: OO, AO, BO, AB, AA and BB. The study results showed that O gene frequency is way higher that of A and then followed by B. It was also found out that frequencies of the blood groups were slightly different between genders. This gender difference could not be considered significant because of the small study sample size. Our results concur with two previous studies by Adrián et. al., (2018) [13] and Sahar et. al., (2007) [14].

The ABO phenotypes express A and B antigens on their cell surfaces which can be used by bacteria, parasites and viruses as attachment receptors and defense mechanisms through molecular mimicry [11]. This makes the A, B and AB phenotypes susceptible to pathogens. Additionally, the O, A and B phenotypes produce Anti-A and Anti-B antibodies which may play a role in destroying microbes hence protecting the affected individuals [6]. In our study, blood group of individuals were predominant over A, B and AB individuals. We also noted that out of 19.3% of individuals who had clinical symptoms, only 2% were blood group O moreover with a single symptom (cough). 17.3% of each of blood group A, B and AB individuals presented with more than three clinical symptoms (cough, fever, noticeable weight loss and night sweats) and this implies the participants had underlying health conditions. Based on the above findings, we believe group O individuals have high immunity against diseases since they lack A and B antigens (the possible microbe receptors) and contain large volumes of Anti-A and Anti-B antibodies that are protective against pathogens. It is important to think that predominance of O allele and phenotype frequencies plays a big role at influencing immunity of a population.

5. Conclusion

Predominance of blood group O over A, B and AB individuals is beneficial and is likely to influence immunity of a given population. This hypothesis is based on the assumption that blood group O individuals have stable immunity and low pathogen susceptibility.

Recommendation

We recommend more studies to elaborate on the role played by blood group O individuals in population disease control.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors declare no conflict of interest.

Statement of ethical approval

Ethical clearance was sought from the Research Ethics Committee of Mbarara University and the Uganda National Council of Science and Technology. Written permission was obtained from Kabarole district Directorate of Health services and Buhinga hospital.

Statement of informed consent

Informed consent was obtained from all the respondents who participated in the study. All their information was kept confidential.

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