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ABO Blood Group System in Genetics

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At the beginning of the 20th century an Austrian scientist, Karl Landsteiner, noted that the RBCs of some individuals were agglutinated by the serum from other individuals. He made a note of the patterns of agglutination and showed that blood could be divided into groups. This marked the discovery of the first blood group system, ABO, and earned Landsteiner a Nobel Prize. Landsteiner explained that the reactions between the RBCs and serum were related to the presence of markers (antigens) on the RBCs and antibodies in the serum. Agglutination occurred when the RBC antigens were bound by the antibodies in the serum. He called the antigens A and B, and depending upon which antigen the RBC expressed, blood either belonged to blood group A or blood group B. A third blood group contained RBCs that reacted as if they lacked the properties of A and B, and this group was later called "O" after the German word "Ohne", which means "without". The following year the fourth blood group, AB, was added to the ABO blood group system. These RBCs expressed both A and B antigens. Karl Landsteiner discovered the ABO blood group system in 1901, which enabled safe blood transfusions. He also co-discovered the Rh blood group system in 1940 and helped identify the polio virus in 1908

Introduction

Human beings can have four types of blood groups *viz*., A, B, AB and O which are controlled by a set of three alleles at one locus (I^A, I^B i^0). Blood contains antigens and antibodies and by the presence or absence of these substances, the blood groups are tested. On the bases of presence or absence of certain antigens, ABO blood groups have been established in human beings by K. Landsteiner in 1900. According to him, two antigens A and B are found in human blood. With these antigenes, certain naturally occurring antibodies in the blood serum are present. General principle of antibody and antigen relationship is that antibodies in a particular individual will be found only for those antigens which are absent in blood of this individual. The status of antigens and antibodies in different blood groups is given in Table 1. Thus, blood from a person of A blood group (donor) can not be transfused into a person of blood group B (recipient) since Anti-A (antibody) present in the serum of recipient will interact with the antigen A and resulted into blood clotting. Similarly, blood from a person of B blood group (donor) can not be transfused into a person of blood group A (recipient) since Anti-B (antibody) present in the serum of recipient will interact with the antigen B and resulted into blood clotting. However, a recipient having blood group AB can be given blood from donors of either A or B blood groups. Since the serum of such recipients has neither Anti-A nor Anti-B. Therefore, individuals with AB blood group are called universal recipients or ACCEPTOR since they can accept blood from donors having either A, B, AB or O blood groups. Similarly, persons of O blood group do not possess A and B antigens, hence O blood can be safely transfused in the person belonging any type of blood group. Therefore, the persons with O blood group are known as universal donors or Purifier blood.

Table.1:Different blood groups in human beings, antigens and antibodies associated with them and their possible genotypes

Types of blood groups	Antigens present (in red blood cells)	Antibodies present (in plasma)	Genotypes
A	A	Anti-B	$I^A I^A$ or $I^A i^0$
B	B	Anti-A	$I^B I^B$ or $i^B i^0$
AB	A + B	Nil	$I^A I^B$
O	Nil	Anti-A + Anti-B	$i^0 i^0$

Antibodies

The ABO antibodies ; anti-A and anti-B are naturally occurring antibodies and are present in the sera of individuals who lack the corresponding antigen. Cells with A antigen will have anti-B in the serum. Cells with B antigen will have anti-A in the serum and cells with AB antigens will not have any antibody. Group O individuals will have both anti-A and anti-B antibodies. These antibodies are IgM in nature.

Genetics

All features in humans are controlled by genes present on chromosomes. Each cell has 23 pairs of chromosomes. There is one locus on chromosome 9 occupied by one of the three alleles A, B, O. The genes of the ABO system are inherited as mendelian codominant. Each individual inherits one gene from each parent. The chromosome from the mother carries one of A,B or O gene. Similarly the chromosome from the father also has one of A, B or O gene. The gene on each chromosome determines the blood group as shown below. The A and B genes are dominant over the O gene.

Inheritance of the ABO System

The ABO blood system is believed to be controlled by a single gene, generally designated as **I.** Gene I has three alleles: $\mathbf{I^A}$, $\mathbf{I^B}$ and $\mathbf{i^0}$. Allele I^A controls the production of antigen A, allele I^B determines antigen B, while allele $\mathbf{i^0}$ does not produce an active antigen (Table 14.1). The hierarchy of dominance relationship is symbolized as $\mathbf{(I^A = I^B) > i^0}$. Both these alleles are co-dominant (Both the alleles of a gene express themselves in the heterozygotes) so that individuals having the genotype I^AI^B have both the antigens A and B on their RBCs (AB blood groups). Individuals with the genotype I^AI^A or I^Ai^0 produce antigen A and are classified into the blood group A; those with genotype I^B I^B or I^Bi^0 produce antigen B and belong to the group B; while those having the genotype i^0i^0 produce neither antigen A nor antigen B and classified into group O (Table 1).

How to test the Blood Groups?

The blood group can be tested in the laboratory with a fairly good degree of accuracy by using Anti-A and Anti-B serums. The serum Anti-A is obtained from persons with B type of blood and the serum will cause the clumping of blood cells (Agglutination) of type A and AB. Similarly, the serum Anti-B is obtained from persons with A type of blood and the serum will cause the clumping of blood cells (Agglutination) of types B and AB. Thus, the four blood group types are done by using both these reactions. The serum Anti-D will cause the clumping of blood cells (Agglutination) in case of Rh positive and no clumping of blood cells (No Agglutination) in case of Rh negative.

Transfusion Reactions

The routine practice of blood typing and cross matching blood products should prevent adverse transfusion reactions caused by ABO antibodies. However, clerical error can result in "the wrong blood" being transfused into a patient, an error which can result in the death of the patient (Sazama, 1985) and (Williamson *et al* 1999). If a recipient who has blood group O is transfused with non-group O RBCs, the naturally occurring anti-A and anti-B in the recipient's serum binds to their corresponding antigens on the transfused RBCs. These antibodies fix complement and cause rapid intravascular hemolysis, triggering an acute

hemolytic transfusion reaction that can cause disseminated intravascular coagulation, shock, acute renal failure, and death. Anti-A1 is a less significant cause of transfusion reactions and does not appear to fix complement.

Procedure

For Identification of Blood Groups

1. Take a microscope slide and mark on its left side Anti-B nd on its right side Anti-Ä.
2. Prick your finger with a sterile needle and leave specks of blood on the slide at two marked places.
3. Add two or three drops of Anti-B serum (yellow) on the left side and Anti-A serum (blue) on the right side of the slide. Generally, it takes 1 to 2 minutes for the reaction, but it is better to wait for about 5 to 6 minutes.
4. See agglutination and type your blood according to the reaction, as given in Table 2.

For Identification of Rh positive or Rh negative

1. Take another microscope slide and mark on it Anti-D.
2. Prick your finger with a sterile needle and leave specks of blood on the slide at marked place.
3. Add two or three drops of Anti-D serum (white**)** on the slide. Generally, it takes 1 to 2 minutes for the reaction, but it is better to wait for about 5 to 6 minutes.
4. See agglutination and type your blood according to the reaction, as given in Table .2.

Table 2: Tick the reaction (in the first three columns) for Agglutination and encircle your blood group and Rh type (in the fourth column).

Anti-A serum (Blue)	Anti-B serum (Yellow)	Anti-D serum (White)	Blood groups and Rh types
Agglutination	No agglutination	Agglutination	A Positive
No agglutination	Agglutination	Agglutination	B Positive
Agglutination	Agglutination	Agglutination	AB Positive
No agglutination	No agglutination	Agglutination	O Positive
Agglutination	No agglutination	No Agglutination	A Negative
No agglutination	Agglutination	No Agglutination	B Negative
Agglutination	Agglutination	No Agglutination	AB Negative
No agglutination	No agglutination	No Agglutination	O Negative

Rh Blood Group System

In addition to the ABO blood grouping system, the other prominent one is the Rh blood group system. About two-thirds of the population contains the third antigen on the surface of their red blood cells known as ***Rh factor*** or ***Rh antigen***; this decides whether the blood group is positive or negative. If the Rh factor is present, an individual is ***rhesus positive*** (Rh+ve); if an Rh factor is absent individual is ***rhesus negative*** (Rh-ve) as they produce Rh antibodies. Therefore, compatibility between donor and individual is crucial in this case as well.

References

1. Landsteiner, K. 1901. Ueber Agglutinationserscheinungen normalen menschlichen Blutes. *Wiener Klinische Wochenschrift*, 46, 1132–1134.
2. Sazama K . Reports of 355 transfusion-associated deaths: 1976 through 1985. Transfusion. 1990;30:583–90.
3. Williamson LM , Lowe S , Love EM , Cohen H , Soldan K , McClelland DB , Skacel P, Barbara JA . 1999.Serious hazards of transfusion (SHOT) initiative: analysis of the first two annual reports. BMJ. 1999;319:16–9.