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Review Article

Blood Group and Genotype

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ABSTRACT

Blood groups are determined by a set of alternative genes and are based on heredity, a fact that is occasionally used to resolve issues of contested parentage. They were once used to show paternity tests and are now employed in forensic science. There are various types of blood groups, but the most prevalent is the ABO blood group system, which includes A, B, AB, and O. The presence of antigens on the surface of red blood cells is used to identify blood groups. Antibodies are naturally formed against ABO antigens that are not present on red blood cells, so people with blood group A will have antibodies B, and those with blood group B will have antibodies A, while people with blood group O will have neither. The rhesus blood grouping system, which uses D antigens and can be positive or negative, is another type of blood grouping. The hemolytic illness of the newborn is the most common disease linked with the rhesus group system. For a long time, blood group and genotype have been a primary issue for prospective spouses, as well as in clinical blood transfusion.

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INTRODUCTION

Blood is a complicated fluid made up of several blood cells suspended in a plasma-like liquid. It is one among the body's connective tissues. Blood is vital to the human system since it is the primary mode of transport for oxygen and is responsible for the provision of nutrients. Blood, above all, serves three critical tasks in the human body: transportation, regulation, and protection. Blood is made up of solid particles and a liquid fluid. Red blood cells, white blood cells, and platelets are the produced constituents. The liquid element of the blood, plasma, distributes nutrients and wastes throughout the body. Proteins, minerals, carbohydrates, lipids, and electrolytes are among the substances that dissolve in plasma (Mitra *et al.*, 2014). The cells and cell fragments are separated from the liquid fluid when a blood sample is spun in a centrifuge. The produced components (red blood cells) are packed in the tube's bottom, and the plasma is the light yellow liquid on top, with white blood cells and platelets forming a layer between the two called the Buffy coat (Cooling, 2015).

The components and functions of blood

Blood's key duties include delivering oxygen and nutrient to tissues and cells, removing waste, and maintaining body pH and temperature (Laura *et al.*, 2018).

Red blood cells

The most abundant of the three types of blood cells in our body is the red blood cell (RBC). They vary because they lack a nucleus, which allows them to be more flexible. They have a biconcave disk shape with a flattened middle. They contain the protein haemoglobin, which transports oxygen from the lungs to the rest of the body. The presence of haemoglobin, which contains iron and binds to oxygen to give blood its red color, also contributes to the red color of the blood. Red blood cells serve as the body's transportation system, transporting oxygen from the lungs to other cells and carbon dioxide

created by the body as waste back to the lungs to be expelled from the body. The kidneys produce a hormone called "erythropoietin," which regulates RBC synthesis in the blood (Syeda and Farhath, 2017). The average lifespan of a red blood cell is only 120 days (Syeda and Farhath, 2017). RBC's primary purpose is to transport oxygen from the lungs to the tissues, where it is utilised as an electron source and for ATP synthesis in the mitochondria. RBC also transfer carbon dioxide from the peripheral to the lungs, where it is expelled. Carbon dioxide is carried in RBC by haemoglobin, which forms carbaminohemoglobin once the amino groups of the haemoglobin chains react. The carbonic anhydrase-catalyzed reaction of CO2 with H2O, followed by H2CO3 deprotonation in water, transports the majority of CO2 in circulation as bicarbonate ions (Thomas *et al.,* 2017). Carbon dioxide can also be transported from the periphery to the lungs by binding carbon dioxide as carbamate to the N-terminal end of the alpha-globin chain and then releasing it as carbon dioxide in the lungs. The red cell, on the other hand, is only responsible for carrying about 15% of the carbon dioxide; the remainder is transferred through the plasma. Deoxyhaemoglobin also helps to produce nitric oxide from nitrite, which can help with peripheral tissue vasodilation. The ability of oxyhaemoglobin to inactivate nitric oxide, which happens when there is intravascular haemolysis, leading to vasoconstriction and a thrombotic tendency, is protected by the confinement of haemoglobin within the red cell (Dean, 2005).

White blood cells

Leukocytes are another name for white blood cells (WBCs). They defend the body from infection and play an important role in the immune system. The presence of a higher number of WBCs in the bloodstream indicates the presence of an infection in the body. They are split into two groups based on whether or not their cells contain granules. Granulocytes and agranulocytes are the two types of cells. Granulocytes are divided into three categories of white blood cells (WBCs). Neutrophils, Eosinophils, and Basophils are the three types of white blood cells. Lymphocytes and monocytes are two subtypes of agranulocytes. By phagocytising germs in our bodies, neutrophils perform a critical function in destroying foreign things, particularly bacteria (Wiggins *et al.,* 2009). The job of Eosinophils is to fight parasitic worm infections by releasing poisons to combat them.Basophils work by producing two chemicals: histamine (which causes allergic reactions) and heparin (which prevents bleeding) (anti coagulant). Monocytes are responsible for the production of macrophages, which phagocytize foreign material. T lymphocytes and B lymphocytes are two types of lymphocytes, which are important white blood cells. T lymphocytes (Thymus-dependent cells) use cell-mediated immunity to attack infected cells and tumors directly. B-lymphocytes (Bursa-dependent cells) are responsible for humoral immunity because they create antibodies that target bacteria, viruses, and other foreign elements selectively (Dannis, 2014).

Platelets

Lymphocytes vary from other WBCs in that they have the ability to remember invading foreign elements. WBCs are found in modest amounts in the blood, typically approximately 1%. They are not only found in the blood, but also in the spleen, thymus, and other organs. Platelets were first characterized by Gulio as "spherules piastrine" (tiny plates) clumping together at a damaged blood vessel site. He also demonstrated that these blood components lacked a nucleus. Platelets are the tiniest blood cells, but they are one of the most important participants in the thrombus development process, according to Obeagu (2018). Platelets are the second most numerous cell type in blood after red blood cells, with counts ranging from 150 to 450, 103 per microliter of blood. To maintain this count, the average adult produces 1011 platelets every day (Thon *et al.,* 2012).

Plasma

Megakaryocytes in the bone marrow produce platelets, which are then discharged into the bloodstream (Patel *et al.,* 2013). By forming a 'platelet plug,' platelets restrict blood loss in primary haemostasis, the physiological mechanism that stops bleeding at a damaged blood artery while maintaining normal blood flow elsewhere in circulation (Thon *et al.,* 2012).Plasma is the blood's liquid component. It's a straw-colored complex solution that's 90% water, with the remaining 10% made up of enzymes, salts, nutrient molecules, dissolved gases, and ions. It acts as a vehicle for supplying nutrients to cells and transferring waste products produced by the kidneys, liver, and lungs' cellular metabolism. Plasma helps to maintain homeostasis by transporting heat throughout the body. Plasma also helps to keep the pH and osmotic pressure in check (Thomas, 2018).

Blood group

The presence or absence of hereditary antigenic compounds on the surface of Red Blood Cells is used to classify blood groups. Proteins, carbohydrates, glycoproteins, and glycolipids are examples of antigens (Thon *et al.,* 2012). Within a given system, blood type refers to a specific pattern of reaction to antisera testing. Over time, knowledge of blood groups has broadened to include not only transfusion-related issues, but also specific diseases linked to RBC surface antigens (Mitra *et al.,* 2014).The International Society of Blood Transfusion now offers 33 blood group systems that represent approximately 300 antigens (Logdberg *et al.,* 2004). The majority of them have been sequenced and

cloned. Except for XG and XK, which are X-borne, and MIC2, which is found on both X and Y chromosomes, the genes of these blood group systems are autosomal. Integral proteins with polymorphisms in amino acid sequence (e.g., rhesus (Rh), Kell), glycoproteins or glycolipids (e.g., ABO) are examples of antigens (Logdberg *et al.,* 2011).

Types of blood groups

The following are the major types of blood group; ABO, MNS, P, Rh, LUTHERAN, KELL, LEWIS, DUFFY, KIDD, DIEGO, CARTWRIGHT (or Yt), Xg, SCIANNA, DOMBROCK, COLTON, LANDSTEINER-WEINER, CHIDO/RODGERS, Hh/BOMBAY, Kx, GERBICH, CROMER, KNOPS, INDIAN, OK, RAPH, JMH, Li, GLOBOSIDE, GIL

The ABO blood group system

Because any person over the age of 6 months has clinically significant anti-A and/or anti-B antibodies in their serum, ABO remains the most relevant of the 33 systems in transfusion and transplantation. Serum from blood group A contains antibodies against blood group B and vice versa, whereas serum from blood group O contains no A/B antigen but both antibodies. H-antigen is the precursor to the antigens that make up the ABO blood groups. It can be found in all RBCs, regardless of the ABO system. Homozygous for the H gene (HH), people with the Bombay phenotype do not express H-antigen on their RBCs. Because H-antigen functions as a precursor, its absence indicates that antigen A and B are not present (Mitra *et al.,* 2014). The ABO gene does not code for ABO antigens directly, but rather for glycosyltransferases, which attach N-galactosamine (group A) or D-galactose (group B) to the H antigen to create the A and B blood group antigens. Individuals in group O do not have this problem, and their red blood cells express the H antigen (Dean, 2005). A lipophilic portion is linked to the red cell membrane, and a carbohydrate chain protrudes above the cell surface, resulting in A, B, and H antigens (Cooling, 2015). During early life, after exposure to the environment, the immune system forms naturally occurring antibodies against those A and B antigens, which are missing, while both anti-A and anti-B antibodies are present in Group O. These are powerful antibodies that cause blood transfusion reactions if incompatible blood is transfused (Cooling, 2015).

The Rh blood group system

The immune system generates naturally occurring antibodies against those A and B antigens that are lacking during early life after exposure to the environment, whereas both anti-A and anti-B antibodies are present in Group O. These are quite effective.After ABO, the Rhesus system is the second most important blood group system (Westhoff, 2004). Currently, the Rh system comprises of 50 blood group antigens, only five of which are significant. An individual's RBC surface may or may not include Rh factor or immunogenic D-antigen. As a result, the condition is classified as Rh-positive (D-antigen present) or Rh-negative (D-antigen absent). Anti-Rh antibodies are not generally found in the blood of people who have Dnegative RBCs, unlike the ABO system, unless their circulatory systems have been exposed to D-positive RBCs (Mitra *et al.,* 2014).

The MNS system

Glycophorin A and Glycophorin B are two genes that make up the MNS antigen system, which was first discovered by Landsteiner and Levine in 1927 (Mitra *et al.,* 2014). The blood group is determined by an autosomal locus on chromosome 4 and a pair of codominant alleles known as LM and LN. Anti-M and anti-N antibodies are IgM antibodies that are infrequently linked to transfusion responses (Agarwal *et al.,* 2013).

Lutheran system

The Lutheran system is made up of four pairs of allelic antigens that each indicates a single amino acid mutation in the Lutheran glycoprotein on chromosome 19. Antibodies to this blood group are uncommon and usually aren't regarded clinically important (Mitra *et al.,* 2014).

Kell system

After the ABO and Rh systems, erythrocyte antigens are the third most potent immunogenic antigens, and they are characterized by an immunological antibody called antiK. Mrs. Kellacher's serum was the first to notice it. She had an allergic reaction to her newborn's erythrocytes, resulting in haemolytic reactions. There have been 25 Kell antigens found since then. Anti-K antibody causes severe fetal and neonatal hemolytic illness (HDFN) and haemolytic transfusion reactions (HTR) (Mitra el al., 2014).

The Duffy Method

Duffy-antigen was discovered in a patient with haemophilia named Duffy. It's also known as Fy glycoprotein, and it's found on RBCs' surfaces. It's a nonspecific chemokine receptor that also serves as a receptor for the human malaria parasite *Plasmodium vivax*. The Duffy glycoprotein antigens Fya and Fyb can result in four different phenotypes: Fy(a+b), Fy(a+b+), Fy(ab+), and Fy(ab). HTR can be caused by antibodies of the IgG class (Luo *et al.,* 2000).

Kidd system

Kidd antigen (also known as Jk antigen) is a glycoprotein found on the surface of red blood cells (RBCs) that functions as a urea transporter in RBCs and renal endothelial cells. Kidd antibodies are uncommon,

although they can result in serious transfusion responses. These antigens are identified by responses to Anti-Jka, an antibody discovered in the serum of Mrs. Kidd, who gave birth to a child with HDFN. The Jka antigen was the first to be discovered using the Kidd blood group system, followed by the Jkb and Jk3 antigens (Mitra *et al.,* 2014). In a study of automated blood group analysis in a north Indian donor community, Agarwal et al. (2013) discovered that the most prevalent blood groups, in order of frequency, were B, O, A, and AB; 94.4% being Rh‑positive. In minor blood groups, the most commonly appearing phenotypes were Le (a−b−) for Lewis, Fy(a+b+) for Duffy, Jk(a+b+) for Kidd, and M+N+ for MNS system.

Genotype

Johann Gregor Mendel was the first to emphasize the hereditary components' stability and integrity (Marianne, 2002). An organism's genotype is the set of inherited instructions stored in its genetic code. Hemoglobin gene constituents are referred to as genotype. Genes are always found in pairs, and whether they are dominant, recessive, or X-linked influences their overall expression. As a result, when one of the genes, such as AS or AC, is abnormal, there is no difficulty. This is referred to as a carrier state (sickle cell trait). Only when both are abnormal is there a serious problem. Human genotypes are AA, AS, AC, and SS (Okoduwa, 2013).The type of protein (haemoglobin) found in red blood cells is determined by blood genotype. In humans, there are four hemoglobin genotypes: AA, AS, SS, and AC. In our blood, we all have a distinct pair of hemoglobin that we inherited from both parents.

Genotypic ratio

After a cross between both parents, this is the number of times a genotype appears in the offspring. The value is determined by the parents' genotype. Punnett square can be used to compute it (Prema and Bhagyalaxmi, 2017). If two creatures with the same genotype (say, Aa) are permitted to mate, their progeny will have the genotype given below:

Table 1: Punnett square showing the genotype of offspring

	A	A
A	AA	Aa
A	Aa	Aa

Genotype disorder

Hemoglobinopathies, or abnormal hemoglobin (Hb) genotypes, are the most frequent human genetic issue, affecting 7% of the world's population. The World Health Organization is concerned about the alarming rate at which it is spreading throughout the world, with more than 70% of countries affected (Onuigwe, 2014). The oxygen carrying capacity of erythrocytes is determined by the genotype of hemoglobin. Normal hemoglobin (HbAA) has a higher affinity for oxygen and transports it to the cells for the creation of energy (ATP). The oxygen carrying capacity of any other variants of the typical hemoglobin HbAA is frequently poor (Akeem, 2016).Low and middle-income countries, particularly Asian and African countries, are the most impacted, with 250,000–300,000 children born each year with variable hemoglobin genotypes, either heterozygous for normal HbA or homozygous for it (Akeem *et al.,* 2016). Although the normal hemoglobin HbAA genotype is the most commonly recorded of these genotypes, variations of HbAA are important because of the clinical difficulties they can induce (Wajeman and Moradkhani, 2011).

The sickle cell disease

Sickle cell disease (SCD) is a set of illnesses marked by sickle haemoglobin. Only two structural hemoglobin (Hb) variants (Hb S and Hb C) achieve high frequencies in Africa, despite the fact that there are over 700 structural hemoglobin (Hb) variants discovered. In this region, homozygous HbSS disease (HbSS), also known as sickle cell anemia (SCA), and Hb SC disease are the most common SCD disorders (Makani *et al.,* 2013). Before the nineteenth century, SCD was known in some regions of Africa: residents of western Africa given disease-specific names that conjure acute, painful events or death, or relate to children doomed to die and be reborn as their own siblings (Onwubalili, 1983).The S mutation is linked to four chromosomal haplotypes. They're called Benin, Senegal, Bantu (Central African Region (CAR)), and Arab-Indian after the countries where they're most common. Restriction fragment length polymorphisms (RFLPs) in the -globin locus define the haplotypes. Because of the haplotypes' demographic exclusivity, it's thought that the sickle cell mutation developed independently in various populations and has persisted to this day (Makani *et al.,* 2013).A replacement of one amino acid (Valine) for another amino acid (Glutamic acid) at position six of the -globin polypeptide chain causes sickle haemoglobin (HbS). A single-base mutation in codon 6 of the -globin gene on chromosome 11 causes this substitution, which results in the sequence GAG rather than GTG. A replacement of one amino acid (Valine) for another amino acid (Glutamic acid) at position six of the -globin polypeptide chain causes sickle haemoglobin (HbS). A single-base mutation in codon 6 of the -globin gene on chromosome 11 causes this substitution, which results in the sequence GAG rather than GTG. When HbS is deoxygenated, it forms lengthy, insoluble polymers due to an aberrant amino acid in the -globin chain, and the red blood cells die.Sickle cell disease can cause a variety of acute and chronic consequences, some of which can be fatal. OCCLUSIVE CRISIS - VASO Sickle-shaped

red blood cells clog capillaries and restrict blood flow to an organ, causing ischaemia, discomfort, and sometimes organ damage. The incidence, severity, and length of these crises varies greatly (Obeagu, 2015).Stem cell transplantation (SCT), which replaces the host's bone marrow with stem cells carrying the normal -globin genotype, is the sole treatment for SCD. Since the first successful transplant in 1984, there has been a significant decrease in risks due to SCT and an increase in success, with the best results, of up to 85% event-free survival, occurring with HLA-matched sibling donors and transplantation early in the disease before end-organ damage occurs (Walters *et al.*, 2000).

Haemoglobin Ac

A structural variant of normal haemoglobin (HbA) is haemoglobin C (HbC), which is generated by an amino acid substitution at position 6 of the b-globin chain (b6Glu-Lys). Along with haemoglobin S, which occurs at the same place (HbS; b6Glu-Val), and haemoglobin E, it is one of the most common aberrant haemoglobin mutations worldwide (HbE, b26Glu-Lys). This characteristic is asymptomatic in HbC heterozygote individuals (AC). Due to the lower solubility of red blood cells, which can lead to crystal formation, homozygosity (CC) causes clinically moderate haemolytic anemia.When HbC is inherited together with HbS (sickle-haemoglobin C disease), it causes chronic haemolytic anemia and intermittent sickle cell crises that are slightly less severe or frequent than in homozygous HbS patients (SS), and when it is co-inherited with b-thalassaemia (haemoglobin C-b thalassaemia), it causes moderate haemolytic anemia with splenomegaly (Frederic *et al.*, 2013).

CONCLUSION

Blood group and genotype are important health factors in our lives. With the knowledge of blood grouping and genotyping health issues like giving birth to sickled cell children can be avoided. In addition, deaths resulting from blood transfusion may be reduced to the minimal level and parental issues will always be resolved.

Recommendations

a. The authors recommend that all individuals should know their blood group and genotype incase of any emergency.

b. The authors recommend that prospective couple should always go for a genotype test before marriage

c. The authors recommend that rhesus factor should always be checked before marriage to avoid diseases like the haemolytic disease of the new born after birth.

CONFLICT OF INTEREST

The authors declare no conflict of interest

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REFERENCES

1. Agarwal, N., Thapliyal, R. M. and Chatterjee, K. (2013). Blood group phenotype frequencies in blood donors from a tertiary care hospital in north India. *Blood Research,* 48: 51-54.

2. Akeem, A., Ebenezer, K. and Musibau, A. (2016). A retrospective study on fourteen year hemoglobin genotype variants recorded at five government hospitals in akure, ondo state, south western Nigeria. *The Egyptian Journal of medical human genetics,* 17: 377-381.

3. Cooling, L. (2015). Blood Groups in Infection and Host Susceptibility. *Clinical Microbiology Reviews,* 28: 801-870.

4. Dean, L. (2005). Blood groups and red cell antigens. National Center for Biotechnology Information (us), chapter 2.

5. Fredenic, B., Rosalind, E., Anand, P., Oscar, A., Peter, W., Samir, B., Thomas, N., David, J. and Simon, I. (2013). The distribution of haemoglobin c and its prevalence in newborns in africa. *Scientific Reports,* 3: 16711.

6. Laura, T., Robert, G., Wallace, P., Cummins, B., Sinead, S., Micheal, H., Niall, M.,Gerardene M., Nastassia N., Marc-antoine C. and Ronan P. (2018). Platelets: from formation to function. *Intecopen,*DOI: 105772.

7. Lögdberg, L., Reid, M., and Zelinski, T. (2011). Human blood group genes 2010: Chromosomal locations and cloning strategies revisited. *Transfusion Medical Review,* 25: 36‑46.

8. Luo, H., Chaudhuri, A., Zbrzezna, V., He, Y. and Pogo, A. (2000). Deletion of the murine Duffy gene (Dfy) reveals that the Duffy receptor is functionally redundant. *Molecular Cell Biology*, 20: 3097‑3101.

9. Makani, J., Ofori-acquah, S., Nnodu, O., Wonkam, A. and Ohene-frempong, K. (2013). Sickle cell disease: new oppurtunities and challenges in Africa. *The Scientific World Journal,* 2013: 16.

10. Marrian, R. (2002). The genotype link. *Hereditus*, 136(1): 1-6.

11. Mitra, R., Mishra, N. and Rath, G. (2014). Blood groups systems. *Indian Journal Anaesthetic*, 58: 524-528.

12. Obeagu, E., Alloy-amadi, O., Ochei, K. and Swem, C. (2018). A review on plateletsand coagulation. *International Journal Current Research Medicine Science*, 4(7): 17-24.

13. Okoduwa, S. (2013). Blood group and genotype compatibility. *Infohealth Awareness Article*, 1(2): 84-87.

14. Onuigwe, F., Babangida, S., Erhabor, O, Abdulrahman, Y., Isaac, Z. and Adias, T. (2014). Prevalence of some hemoglobin variants among students of Usmanu Danfodio University, Sokoto, north western Nigeria. *International Joural of Clinical Medicine Research*, 1(4): 166-171.
15. Patel, S., Dhillon, M., Aggarwal, S., Marwaha, N. and Jain, A. (2013). Treatment With platelet-rich plasma is more effective than placebo for knee osteoarthritis: A prospective, doubleblind, randomized trial. *The American Journal of Sports Medicine*, 41(2): 356-364.
16. Prema, G. and Bhagyalaxmi, M. (2017). Genotype. *Encyclopedia of Animal Cognition and Behavior*, 68: 1.
17. Syeda, J. and Farhath, k. (2017). Blood cells and leukocyte culture: a short review. *Access blood research and transfusion journal*, 1(2): 2575-8934.
18. Thomas, k., Wiebke, L., Christian, M. and Christina, P. (2017). Red blood cell function and dysfunction: redox regulation, nitric oxide metabolism, anaemia. *Antioxidants and redox signaling*, 10(00): 16.
19. Thon, J., Peters, C., Machlus, K., Aslam, R., Rowley, J. and Macleod, H. (2012). T granules in human platelets function in TLR9 organization and signaling. *The Journal of Cell Biology*, 198(4): 561-574.
20. Thomas, L. (2018). Blood plasma components and functions. *News Medical.* Retrieved on August 27, 2021 from https://www.news-medical.net/health/blood-plasma-components-and -function,aspx.
21. Wiggins, K., Smith, N., Glazer, N., Rosendaal, F., Heckbert, S. and Psaty, B. (2009). ABO genotype and risk of thrombotic events and hemorrhagic stroke. *Journal of Thrombosis Haemostasis*, 7: 263‑269.