# THE BOMBAY BLOOD GROUP-HOW DOES IT FIT IN THE HUMAN BLOOD GROUP

THOMAS F. FREEMAN HONORS COLLEGE

SENIOR THESIS

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B.S. CLINICAL LABORATORY SCIENCE

COLLEGE OF PHARMACY AND HEALTH SCIENCES

MAY 2021

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ABSTRACT

THE BOMBAY BLOOD GROUP: HOW DOES IT FIT IN THE HUMAN BLOOD GROUP

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The Bombay blood phenotype is one of the rarest ABO blood group. It is autosomal recessive allele and occurs due to a point mutation in the FUT1gene on chromosome 19. The H gene synthesizes the H antigen which is located on the red blood cells (RBCs). This thesis analyzes the Bombay phenotype, more specifically how it fits in the human blood group. It questions whether the differences between the Bombay phenotype and the ABO blood group affects its place as an actual blood group. The goal of this study is to increase the amount of knowledge regarding the Bombay phenotype and the human blood group system.

## Table of Contents

List of Tables

LIST OF FIGURES

Page

# VITA

Maya R. Davis was born in Kingston Jamaica where she resided until she moved to the United states in 2011. She attended Truman State University in Kirksville Missouri, and in August 2015 she received the degree of Bachelor of Science in Biology. She entered Texas Southern University in August 2017 and received a Bachelor of Science degree in Clinical Laboratory Science in May 2021.

# DEDICATION

This thesis is dedicated with love and gratitude to my sister and to all other strong women in my life, who, have nurtured and contributed greatly to the growth and development of my character.

ACKNOWLEDGEMENTS

Thank you to my advisor, Dr Monica Rasmus., for providing guidance and feedback throughout this project. Thanks also to my family, for providing moral support and for providing guidance and a sounding advice when required.

# CHAPTER I: INTRODUCTION

The human blood group most commonly includes the ABO blood group system and the Rh system. Together, these two attributes form the blood group system that most people are familiar with. The ABO blood group consists of four basics phenotypes which are Type O, A, B, and AB. Each phenotype can be RhD positive or RhD negative to give a total of eight basic blood types. The grouping system is based on the premise that individuals have antigens on their red blood cell membrane that corresponds to the four main blood groups. These antigens are types of proteins found on the red blood cells. In rare cases, there are individuals who do not express the H antigen, these individuals are said to have an H antigen deficiency known as the Bombay phenotype (hh).

The Bombay blood phenotype is one of the rarest ABO blood groups and was discovered in Bombay, now modern-day Mumbai, by Dr. Y. M. Bhende in 1952. It is transmitted as an autosomal recessive trait and describes individuals that lack the H antigen on their red blood cells (RBCs). Bhende and his co-authors published their paper in 1951 after months of research. The phenotype was further classified into Bombay and para-Bombay phenotype based on the absence of the H antigen. The Bombay phenotype is mostly found in 1 of 10,000 individuals in India and parts of the Middle East. Since there is an absence of H antigen expression on the red cell membrane of the ABO blood group system, blood donations usually have to come from a suitable relative of patients in need of a blood transfusion. The Bombay phenotype is a result of a point mutation in the FUT1 gene which is involved in the synthesis of the H antigen. The H antigen is a precursor to the A and B antigens. Individuals with the Bombay phenotype are H deficient and therefore cannot synthesize the A or B antigens. The ABH antigens are therefore

absent from their red cells. The blood group shows the presence of anti-A, anti-B, and strong anti-H antibodies in their plasma. Because of this, the Bombay phenotype was initially recognized as O group.

# REVIEW OF LITERATIRE

Many people have never heard of the term Bombay phenotype. Most people, however, are familiar with the ABO human blood group system. The Bombay phenotype is one of the rarest ABO blood group (Bhende et al,1952). The Bombay phenotype lacks the two genes that encode for the enzyme to make the H antigen, their genotype is hh and sese. (Watkins & Morgan, 1955). People having Bombay phenotype inherit the homozygous recessive genotype (hh) instead of the homozygous dominant (HH) or heterozygous (Hh) genotypes associated with the ABO blood group system (Awan et al, 2018). Indians have been found to exhibit this phenotype the most. Bhende and company discovered this blood group in Bombay India after observing that the new blood group had serum which contained antibodies that attacked the normal ABO red blood cells. The phenotype is so rare that in India, 1 in 10,000 people have it (Dipta &Hossain, 2011). Bombay is mostly reported in people of India descent. However, while the phenotype is mostly seen among Indians and people of Indian descent, this may not necessarily mean it's not seen in other parts of the world. In Europe, the prevalence of the Bombay phenotype is $1{:}10^6$. It is also very rare in Caucasian with an incidence of 1 in 250,000 (Dipta & Hossain, 2011).

The ABO blood group system is the most popular system and denotes the presence or absence of one or two antigens on the red blood cells. It was discovered in 1901 by Karl Landsteiner at the University of Vienna. In 1930, he posthumously received the Nobel Prize for discovering the blood types (Harmening, 2018). It is used as a means of classifying human blood and involves two antigens, antigen A and antigen B, and two antibodies, antibody A and antibody B. The antigens are present on the surface of the red blood cell while the antibody is in the serum. Within the ABO blood group system there are four basics phenotypes which are Type O, A, B, and AB. Each blood group can be RhD positive or RhD negative.

According to the American Red Cross the most common blood type statistically in the US is shown in Table 2. Type O negative and O positive blood are constantly in high demands. Only about 7% of the population are O negative. Approximately 37% of Caucasians are blood type O positive, but 47% of African Americans are type O positive and 53% of Latin Americans are type O positive (American Red Cross, n.d.).

Second to the ABO system is the Rh system. The Rh system explains that the red blood cell has an antigen on its surface called the Rh antigen. The Rh blood group is important because of the fact that its antigens are highly immunogenic. The Rh status is routinely determined in persons donating blood. (Dean & Dean, 2005).

While the Bombay phenotype is not popularly known, it is important to note that there are other blood groups recognized by the International Society of Blood Transfusion (ISBT). In 2019, the International Society of Blood Transfusion (ISBT) have recognized a total of 41 human blood group systems (Storry, 2019). The para-Bombay type is different from the Bombay phenotype in that the former has H antigens in its secretions, whereas the latter doesn't. (Kim et al, 2019).)

Genetic analysis of the Bombay phenotype shows that it is as a result of a homozygous recessive gene which prevents the development of A, B, and H antigens. (Yunis et al, 1969). It is as a result of a point mutation in the FUT1 gene, with a deletion of exon 2 on FUT2 (Daniels, 2008). Bombay blood group is easily mistyped as blood group O so proper testing should be done to detect the Bombay phenotype. Mistyping the Bombay phenotype can lead to an adverse reaction during blood transfusion. (Nikam et al, 2017)

A blood transfusion is a lifesaving routine procedure but for individuals with the Bombay phenotype it is quite difficult. As demonstrated, the Bombay phenotype lacks the H antigen on their red blood cells, so transfusion between the ABO blood group can cause a hemolytic transfusion reaction (Nikam et al, 2017). Individuals with the Bombay phenotype can donate blood to those individuals that's a part of the ABO blood group system, but they cannot receive blood. In Shahshahani and company's (2013) case report on transfusion reaction with the Bombay blood group, they found that individuals having the Bombay phenotype are easily misdiagnosed as the Type O blood group. They noted that a person who has Bombay phenotype may have a hemolytic transfusion reaction if transfused with the wrong blood. A person having the Bombay phenotype has to be transfused with someone else of the same phenotype (Knowles, 2006).

Hemolytic transfusion reaction is often associated with the Bombay phenotype. As demonstrated in Shastry et al, (2013) case report, there can be severe hemolytic disease of the newborn if the mother is Bombay phenotype. Because of the rarity of the phenotype individuals with Bombay can receive blood in one of two ways: by doing an autologous blood donation prior to surgery or transfusion from another Bombay Blood group (Shahshahani et al, 2013). If a person with the Bombay phenotype gets blood from a donor with the ABO blood type, a hemolytic transfusion can occur due to the bloods being incompatible. According to the same case report, HDN is theoretically possible in babies with Bombay phenotype but there are practically no reports in literature on it (Shastry et al, 2013). It is therefore important that proper blood grouping takes place.

The Bombay phenotype is a blood group that is very rare. However, further study of the differences between it and the ABO blood group will lead to better understanding. Specifically,

transfusion between both blood groups should be studied in order to learn what makes the Bombay phenotype incompatible among the ABO blood types and if there is any successful way to overcome that. Therefore, the following research question is raised

RQ: How does the Bombay phenotype fit in the human blood group?

# CHAPTER II: THE HUMAN BLOOD GROUP- AN OVERVIEW OF THE ABO BLOOD TYPE AND THE BOMBAY BLOOD TYPE

The human blood type is a way to classify the human blood based on the presence or absence of antibodies and antigens, including the Rh factor on the surface of the red blood cells (RBCs). These antigens are a type of protein found on the red blood cells. As of 2019, the International Society of Blood Transfusion (ISBT) have recognized a total of 41 human blood group systems (Storry et al, 2019). Some of these blood groups are highlighted in Table 1. The blood types in the ABO and RhD system are the most important and known blood group system as they determine someone's blood type. The ABO blood group system was discovered in 1901 by Karl Landsteiner at the University of Vienna while he was in the process of trying to figure out why blood transfusions sometimes cause death and in other cases saves a patient's life. In 1930, he posthumously received the Nobel Prize for discovering the blood types (Harmening, 2018). The ABO blood group system is a means of classifying human blood based on inherited genes from both parents. It involves two antigens, antigen A and antigen B, and two antibodies, antibody A and antibody B. The antigens are present on the surface of the red blood cell while the antibody is in the serum. The ABO blood group consists of four basics phenotypes which are Type O, A, B, and AB. Each blood group can be RhD positive or RhD negative. Combining these two characteristics creates eight basic blood types (O-positive, O-negative, A-positive, A-negative, B-positive, B-negative, AB-positive, AB-negative).

Whole blood is blood that runs through the veins, it contains erythrocytes, white blood cells, plasma and platelets. The many components of blood give it its ability to perform various functions including, transportation of oxygen around the body, forming blood clots to stop excessive bleeding and carrying antibodies that combat infection. The human blood group is

identified by antibodies and antigens in the blood. Antibodies are soldiers that are part of the bodies defense systems. These antibodies fight against foreign invaders which might pose a threat to the body. Antigens are protein molecules that are found on the surface of red blood cells. The four main blood groups defined by the ABO system with the presence or absence of antibodies and antigens are grouped as follows:

Blood group O – has no antigens, but has both anti-A and anti-B antibodies in its plasma
Blood group A – has A antigens on the red blood cells and has anti-B antibodies in the plasma
Blood group B – has B antigens with anti-A antibodies in its plasma
Blood group AB – has both A and B antigens, but no antibodies
Table 2 shows the possible way antibodies and antigens with corresponding ABO type.

Humans with blood type B will have antigen B on the surface of their red blood cell which will then prevents them from producing anti-B antibodies. Persons having blood type O do not have any AB antigens, this makes blood type O universal donors for transfusion as it is not rejected from others. Individuals having blood type AB do not produce AB antigens which makes them good receivers for blood transfusion. It is estimated that 5% of the US population has blood type AB, with 1% having AB negative (AB-) blood and 4% having AB positive (AB+) blood (American red Cross, n.d.). The AB negative is the least common blood type among Americans and individuals having this blood type can receive blood from all other negative blood types. The ABO blood group system is the most important blood group system in human blood transfusion reactions. O negative blood is routinely used in transfusion for any blood type. It is routinely in short supply because it is the universally donated blood needed for emergency transfusion (American Red Cross, n.d.).

The Rh system is the second most import blood group system and was discovered in 1940 by Karl Landsteiner and A.S. Weiner. The most important antigen in the Rh system is the D-antigen. The Rh system explains that the red blood cell has an antigen on its surface called the Rh antigen. When the antigen is present the individual is termed Rh positive (Rh+). But, if absent the individuals in this blood group are described as being Rh negative (Rh-). The Rh blood group is important because of the fact that its antigens are highly immunogenic. It's solely for this reason the Rh status is routinely determined in persons donating blood. (Dean & Dean, 2005).

According to the American Red Cross the most common blood type statistically in the US is shown in the Table 2. Type O negative and O positive blood are constantly in high demands. Only about 7% of the population are O negative. Approximately 37% of Caucasians are blood type O positive, but 47% of African Americans are type O positive and 53% of Latin Americans are type O positive. This indicates the critical role the minority group plays in meeting the need for blood (American red Cross, n.d.). Table 3 shows the rarest blood types. A person's blood type is considered rare if they lack an antigen for which 99% of the population is positive. If they lack an antigen that 99.99% of the people have, then that blood type is considered to be extremely rare. To date, the American Red Cross has listed 600 known antigens which contributes to the nature of blood based on their presence or absence (American Red Cross, n.d.).

It is important to note that the Bombay phenotype is one of the rarest ABO blood groups. In the 1950s, Bhende et al. discovered a new blood group in Bombay India (now known as Mumbai). He described the blood group after observing an individual with an unusual blood type having a strange reaction to other ABO blood types. (Bhende et al,1952) This new blood group is

now called the Bombay phenotype. Dr. Bhende observed that the new blood group had serum which contained antibodies that attacked the normal ABO red blood cells. The Bombay phenotype is very rare and reportedly it occurs with a frequency of 1 in 10,000 people in India. (Dipta & Hossain, 2011). The phenotype is mostly reported in people of India descent. In Europe, the prevalence of the Bombay phenotype is $1:10^6$ (Dean & Dean, 2005).

It is also very rare in Caucasians with an incidence of 1 in 250,000. (Dipta &Hossain, 2011). Because of its failure to express the H antigen on the red cell membrane of the ABO blood group system, blood donations usually have to come from a suitable relative. Individuals with Bombay phenotype lack the two genes that encode the enzyme to make the H antigen, their genotype is hh and sese. (Watkins & Morgan, 1955)

Para-Bombay type and Bombay phenotype are both rare phenotypes that have defects in producing the H antigen. The para-Bombay type is different from the Bombay phenotype in that the former has H antigens in its secretions, whereas the latter doesn't. (Kim et al, 2019).

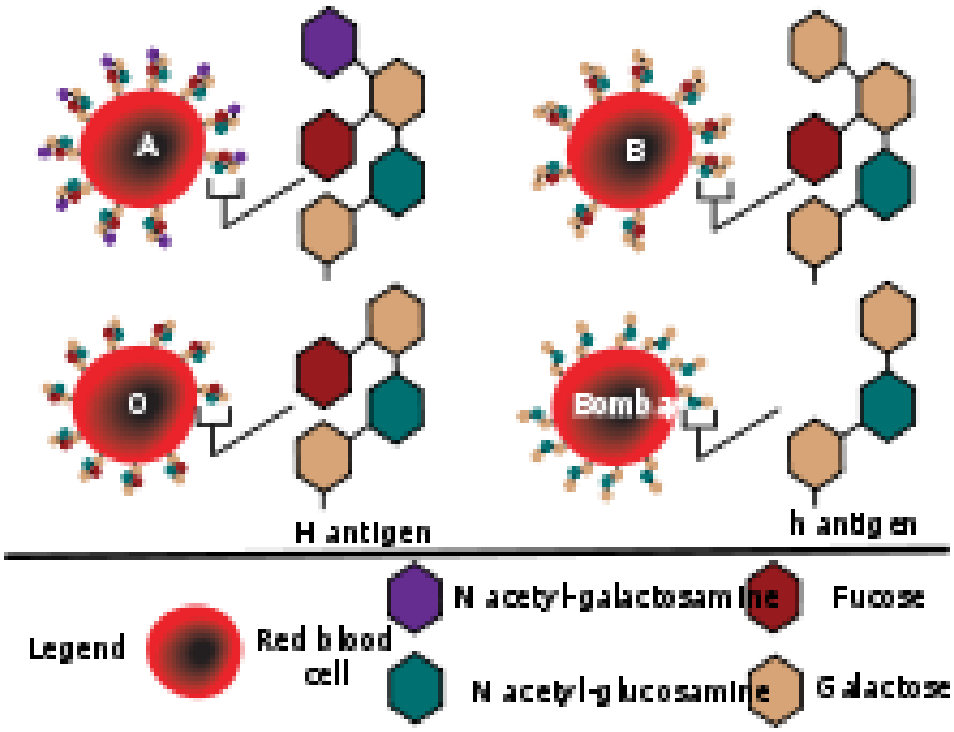


Figure1: Diagram Showing the molecular structure of the ABO (h) antigen system

Table 1: Blood Group System

| Name | Symbol | Number of antigens | Gene name | Chromosome |
|---|---|---|---|---|
| ABO | ABO | 4 | ABO | 9 |
| MNS | MNS | 43 | GYPA, GYPB, GYPE | 4 |
| P | P1 | 1 | P1 | 22 |
| Rhesus | Rh | 49 | RhD, RhCE | 1 |
| Lutheran | LU | 20 | LU | 19 |
| Kell | KEL | 25 | KEL | 7 |
| Lewis | LE | 6 | FUT3 | 19 |
| Duffy | FY | 6 | FY | 1 |
| Kidd | Jk | 3 | SLC14A1 | 18 |

Table 2: Antibodies and Antigens with corresponding ABO type.

| ABO Blood Type | Antigen A | Antigen B | Antibody anti A | Antibody anti B |
|---|---|---|---|---|
| O | **N** | **N** | **Y** | **Y** |
| A | **Y** | **N** | **N** | **Y** |
| B | **N** | **Y** | **Y** | **N** |
| AB | **Y** | **Y** | **N** | **N** |

Table 3: Most Common Blood type by Ethnicity in the US

| Ethnicity | O positive (%) | A positive (%) | B positive (%) |
|---|---|---|---|
| African American | 47 | 24 | 18 |
| Latin American | 53 | 29 | 9 |
| Asian | 39 | 27 | 25 |
| Caucasian | 37 | 33 | 9 |

Table 4: Most Rare Blood Type by Ethnicity in the US

| Ethnicity | AB negative (%) | B negative (%) | A negative (%) | AB positive (%) |
|---|---|---|---|---|
| African American | 0.3 | 1 | 2 | 0 |
| Latin American | 0.2 | 1 | 2 | 2 |
| Asian | 0.1 | 0.4 | 0.5 | 0 |
| Caucasian | 1 | 1 | 0 | 3 |

## CHAPTER III: THE BOMBAY BLOOD GROUP GENOTYPE- WHAT'S THE DIFFERENCE BETWEEN THE ABO BLOOD GROUP?

The ABO gene is located on chromosome 9 at the band 9q34.2 and contains 7 exons that encode a 354-aa glycoprotein. The gene encodes three alleles which are A, B, and O allele. Chromosome 9 encodes for the A and B glycosyltransferase which are the transferase necessary for the ABO antigens. The FUT1 gene, is located on chromosome 19q13.3 where the synthesis of A, B and H antigens occurs. The FUT2 gene is also located on chromosome 19q13.3, however, it encodes for the transferases essential to the production of the ABO antigens that are associated with bodily fluids other than blood (Awan et al, 2018).

The rare Bombay blood phenotype occurs in people who inherited two recessive alleles of the H gene making their genotype hh. These individuals have no H antigen on the surface of their red cells or in their secretions. In other words, they possess the alleles for either or both of the A and B alleles, but they are not able to express them. It is a condition that is mainly seen in closed off communities such as noble families where they inbreed because of their customs. There is a lack of genetic variety in these types of communities.

This phenotype is a result from homozygosity of a point mutation in the FUT1 gene, with a deletion of exon 2 on FUT2 (Daniels, 2008). The Tyr316Ter mutation in the coding region of FUT1introduces a stop codon, leading to a reduction in enzyme that lacks 50 amino acids at the C-terminal end, causing the enzyme to be inactive. There has to be at least one useful copy of FUT1 present (H/H or H/h) for the H antigen to be produced on the surface of the red blood cells. The Bombay phenotype results if both copies of FUT1 are inactive. The H antigen must be synthesized before the A of B antigen can be made (Dean &Dean, 2005). Chromosome 19 produces glycosyltransferase that add L-fucose to a precursor ingredient to make H antigen on red cells. H antigen is an essential substance to the A or B transferase which are encoded by the

ABO gene (Shahshahani et al, 2013). This A and B transferase converts the H antigen into either A or B antigen. Blood group A individuals express an α1-3 N-acetylgalactosamine (GalNAc), and blood group B individuals express an α1-3 galactose (Cooling, 2015). The O allele in type O individuals, produces a transferase that is inactive. So, group's O individuals have indolent ABO genes and only express the H-antigen precursor.

Watkins and Morgan postulated that there are two types of Bombay genotype. They further go on to state that there is a large number of Lewis positive Bombay individuals. In a report by Yunis et al (1969), the authors describe a large family, covering three generations that has a greater number of Bombay individuals than in any other previous studies. The report demonstrates the inheritance of the Bombay phenotype in offspring from the union of Bombay phenotype hh and an individual heterozygous Hh at the Bombay locus. The family shows the suppression of the A-B-O phenotype by way of the Bombay phenotype and also the heterozygosity at the Lewis Locus. This is consistent with the scheme postulated by Watkins of the Bombay phenotype having two types of genotype (Yunis et al, 1969).

The main characteristic feature of the Bombay phenotype which is its lack of H antigen highlights the main difference between the Bombay blood group and the ABO blood group, in particular the O group. The O blood group contains the highest amount of H antigens among all the blood phenotypes. Additionally, the Bombay blood group includes anti-H in the plasma while group O blood does not have anti-H in the plasma. The genomic make-up of the Bombay blood group is h/h; se/se while the genotype of the O blood group is H/H or H/h and Se/Se or Se/se. Another difference between Bombay blood group and O blood group is that Bombay blood group contains two recessive alleles however, the group O blood contains at least a single dominant H allele. (Dean &Dean, 2005)

The similarities that exist between the blood groups are that they are blood phenotypes that both occur among humans. They are both distinguished by the presence or absence of the H antigen on the surface of the red blood cells. Both blood groups contain anti-A and anti-B antibodies in the plasma.

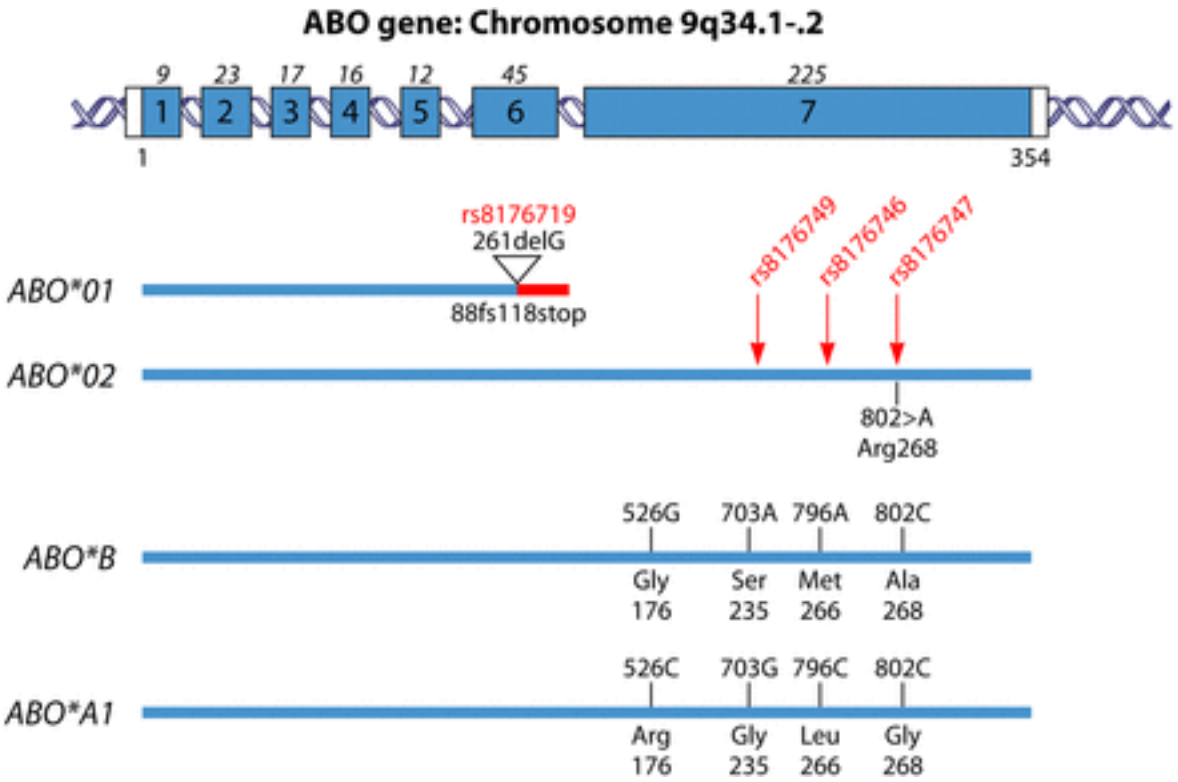

Figure 2: ABO gene and major A, B, and O alleles

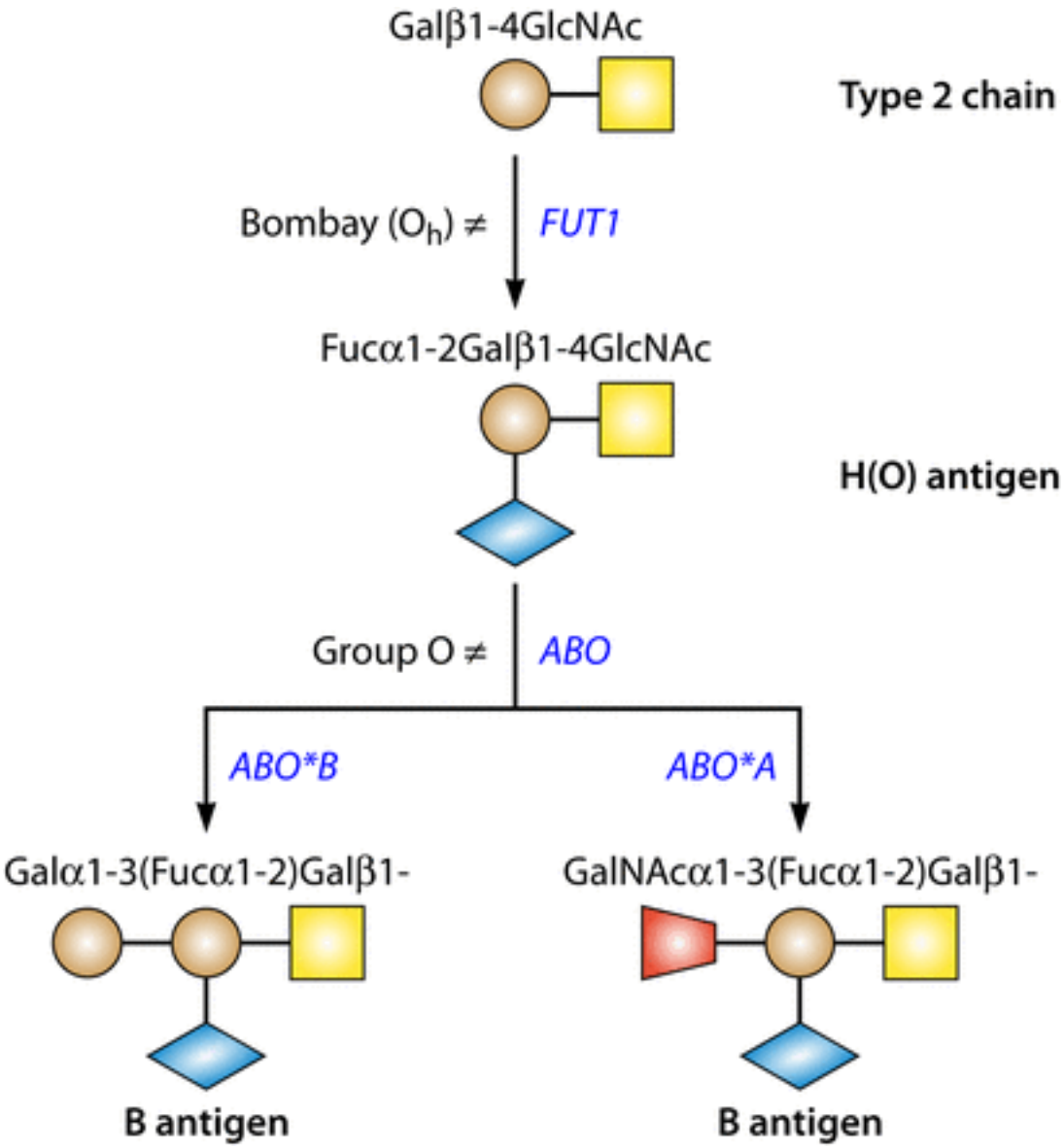


Figure 3: Showing Synthesis of H, A, and B antigens.

Table 5: ABO Genotyping

| | **Antigens present of RBCs** | **Antibody present in plasma** | **Possible Genotype** |
|---|---|---|---|
| *A* | A antigen | Anti-A | AA or AO |
| *B* | B antigen | Anti- B | BB or BO |
| *AB* | A antigen<br><br>B antigen | none | AB |
| *O* | None | Anti-A, anti-B, anti-A, B | OO |

## Chapter IV: THE BOMBAY BLOOD GROUPS – TESTING AND TRANSFUSION LIMITATIONS

Genetic analysis of the Bombay phenotype shows that it is as a result of a homozygous recessive gene which prevents the development of A, B, and H antigens. (Yunis et al, 1969). It shows that the Bombay phenotype is an H antigen deficient phenotype. Bombay blood group is easily mistyped as blood group O so proper testing should be done to detect the Bombay phenotype. Mistyping the Bombay phenotype can lead to a transfusion reaction during blood transfusion.

It is difficult for individuals with the Bombay phenotype to receive blood when there is a need. Individuals with Bombay can receive blood in one of two ways: by donating their own blood prior to transfusion or receive it from another Bombay Blood group (Shahshahani, et al 2013). Blood transfusion is a way of adding blood or blood components such as plasma and platelets to the body. It is a routine medical procedure provided to the recipient through a tube placed in the vein of the forearm. Blood types are important in transfusion. If you get a transfusion that's incompatible with your blood type, your body's immune response is to fight the donor's blood. Allergic reactions are the most common type of transfusion reactions. Allergic reactions occur when the body reacts to the plasma proteins or other substances in the donated blood. Usually, the symptoms are mild and include, itching and hives which is treated with antihistamines. In very rare cases, the reactions can be more severe. (American Cancer Society, 2017). An acute hemolytic transfusion reaction is another form of reaction that is the most serios type of reaction. It occurs when the blood donor and the recipient blood type do not match. The reaction occurs when the transfused red blood cells are attacked by the patient's antibodies causing the red blood cells to be hemolyzed and release harmful substances into the body's blood

stream. Patients experience acute hemolytic transfusion may have chills, fever, lower back pain and nausea. In some situations, the reaction can be become deadly if the transfusion is not stopped. Delayed hemolytic transfusion happens days or weeks after the transfusion. This type of transfusion occurs in a person who had a transfusion in the past. It involves the body attacking the antigens on the transfused blood cells days or weeks after the transfusion (American Cancer Society, 2017).

Hemolytic disease of the newborn could arise in mothers with the Bombay phenotype. Hemolytic disease of the newborn occurs when the baby's red blood cells goes through hemolysis. It occurs due to the mother's IgG antibodies crossing the placenta leading to hemolysis (Narang & Jain, 2001). Shastry *et al* described a rare case of severe hemolytic disease with a young mother with Bombay phenotype. The mother's blood is wrongly typed as O positive. In this case there were two factors which could have caused the hemolytic disease of the newborn. Firstly, doctors suspected it was because of the anti A present in the mother, as the baby's blood group was 'A' positive. Secondly, doctors thought the mother was mistyped and there was the anti H present in the Bombay phenotype mother. The first possibility was ruled out due to the baby's incompatibility with the mothers O positive blood. The error in the mother's blood group was noted and the hemolysis of the baby's red blood cells was due to the Oh phenotype of the mother (Shastry et al, 2013).

Bombay phenotype blood transfusion is complicated given the fact that phenotype lacks A and B antigens. When individuals with the Bombay phenotype needs a blood transfusion, they can only receive autologous blood or blood from another Bombay blood group individual. Even though blood group O has no H antigen, transfusing the red cell blood group O to a Bombay phenotype can cause a fatal hemolytic reaction. (Shahshahani, et al, 2013)

Individuals with the Bombay phenotype can be donors to all ABO blood groups but they can't receive blood. They can only accept blood from a Bombay phenotype person. This is because all ABO donors have the H antigen common in their ABO blood group. This makes the Bombay phenotype incompatible with ABO donors. Given the rarity of this blood group, anyone who needs immediate blood transfusion would be unable to be transfused because no blood would be at the blood bank. Those anticipating the need for this blood would probably have to do an autologous donation. but this case is not an option when there is an emergency transfusion. (Nikam et al, 2017).

In a case report by Shahshahani and her co-authors, it was noted how a patient admitted to the hospital was mistyped and her blood group was thought to be O. A unit of blood group O was given to the patient during transfusion. The patient had a transfusion reaction which caused doctors to stop transfusion immediately. Further testing on the patient's blood revealed that the patient was not blood type O but actually Bombay phenotype. Bombay phenotype is often misdiagnosed as the blood group O because of the presence of anti-H in their plasma. A transfusion reaction between blood group O would result in a hemolytic transfusion reaction. (Suraci & Mora, 2016).

In order to avoid transfusion reactions, it is important to perform both forward and reverse ABO blood typing. Standard crossmatching and pretransfusion laboratory test should also be formed in blood banks in the hospitals. (Shahshahani, et al 2013). Table 5 illustrate forward and reverse grouping with the blood groups. It is shown how, Bombay blood group would be considered as O group because it doesn't show any reaction to anti-A and anti-B antibodies during forward grouping. When it is cross matched with different units of blood O group, it would show incompatibility (Suraci & Mora, 2016). Therefore, additional test such as

reverse grouping has to be performed in order to confirm the Bombay phenotype. It has been suggested to “routine serum typing or reverse grouping confirmation” along with “O” cell control in reverse grouping be incorporated in procedures in every blood bank or transfusion medicine department. (Dipta &Hossain, 2011). In 2019, the Indian express stated that there was an unofficial registry for Bombay blood group that lists over 350 donors across India. However, these donors are not always available, in fact, at any time there are only 30 active donors available to give blood (Barnagarwala, 2019). The Bombay group is generally not stored in blood banks, mainly because it is rare, and the shelf life of blood is 35-42 days so whenever there is a demand a patient is required urgently. (Barnagarwala, 2019)

Having the Bombay phenotype does not mean a person suffers from poor immunity or may be more prone to diseases. Their counts for haemoglobin, red blood cells, platelets, and white blood cells, are similar to the count of others based on their health index. Because of rarity, however, they do face problems during blood transfusion. (Barnagarwala, 2019)

The Bombay blood group is the rarest ABO blood group discovered over 60 years ago. It is rare in India and even rarer globally. Globally the incidence of the phenotype is one in four million. This blood group is easily mistyped as the ‘O’ blood type because it does not show any reaction to anti-A and anti-B antibodies just like the normal ‘O’ group. The difference in both blood groups is that the O group has Antigen H, while the Bombay (hh) group does not. Red cells of the Bombay group are only compatible with the serum from another Bombay individual. Individuals with Bombay blood group can donate to all ABO blood group but can only accept from other Bombay blood group people. The Bombay serum has anti-H is an IgM antibody that can bind complement and cause red cell lysis. Bombay blood is incompatible with all ABO

donors because the H antigen is common to all ABO blood group red blood cells. In context, cross-matching reverse grouping or serum grouping has to be done to detect this group.

Table 3. Forward and reverse Grouping with Blood Types (+) =Agglutination, (-) = No reactivity

| Blood Group | Forward Group | | | Reverse Group | | |
|---|---|---|---|---|---|---|
| | Anti-A | Anti-B | Anti-A,B | A1 Cells | B Cells | O Cells |
| A | + | - | + | - | + | - |
| B | - | + | + | + | - | - |
| AB | + | + | + | - | - | - |
| O | - | - | - | + | + | - |
| Bombay | - | - | - | + | + | + |

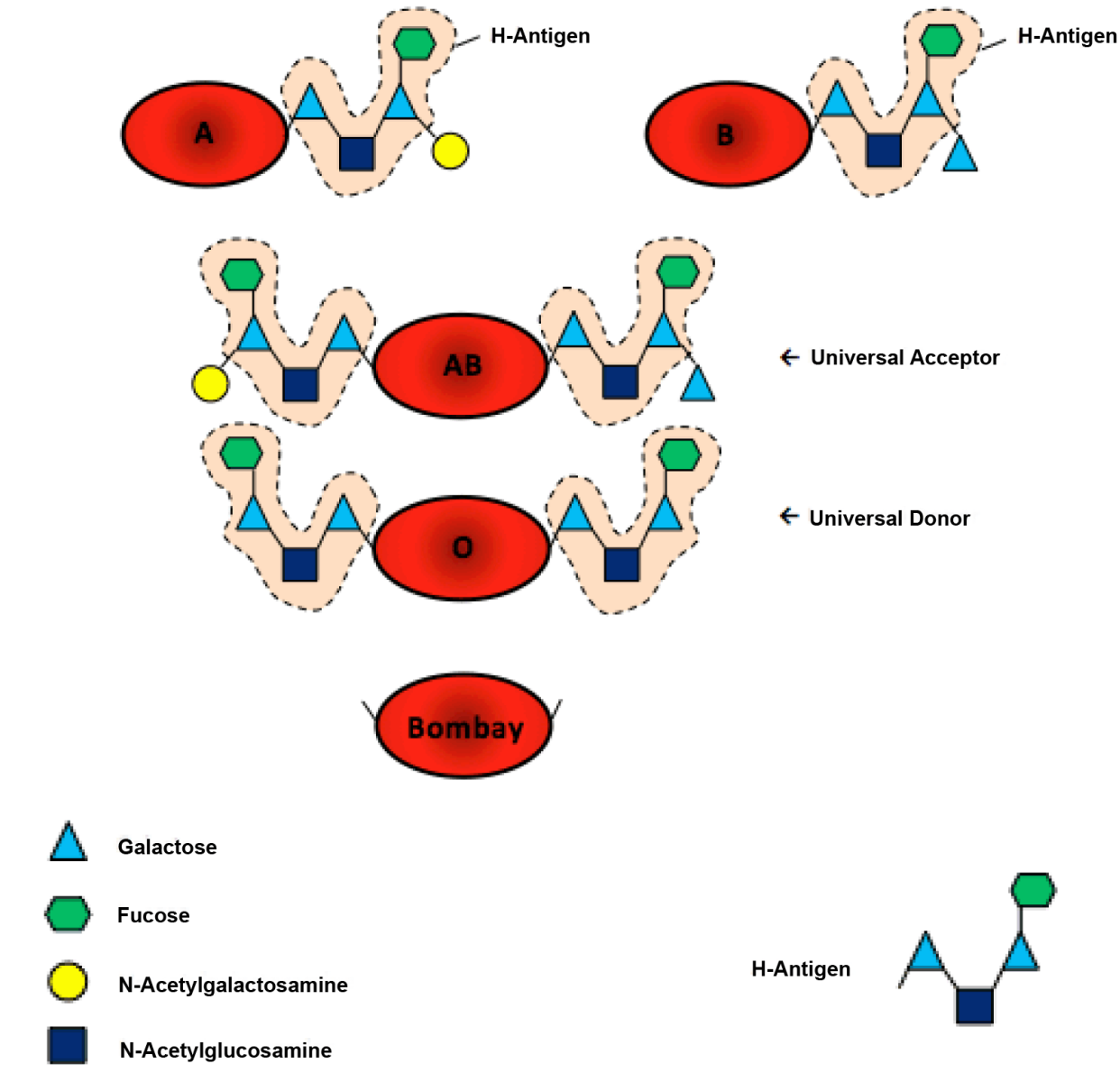


Figure 4: Showing the Structural Component of Blood Group Phenotype.

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