



Perspective of Red blood cell (RBC) alloimmunization

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DOI: 10.5281/zenodo.15331058

Submission Date: 28 March 2025 | Published Date: 03 May 2025

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Abstract

The red cell alloimmunization happens when the immune system creates antibodies against the antigens of another person, usually during pregnancy or blood transfusions. Pregnancy-related hemolytic disease of the fetus and newborn (HDFN), which can result in anemia, hydrops fetalis, or stillbirth, is frequently caused by Rh or other red cell antigens that the fetus inherits from the father. The diagnosis is made by checking for maternal antibodies and keeping an eye on the health of the fetus using Doppler or ultrasound tests. In order to prevent sensitization in Rh-negative mothers, treatment consists of intrauterine transfusions for fetal anemia, Rh immunoglobulin (RhoGAM), and, if required, an early delivery. Blood transfusions can cause hemolytic responses or platelet refractoriness due to alloimmunization caused by mismatched blood components. While immediate treatment entails stopping the transfusion and offering supportive care, prevention focuses on matching blood types between donors and recipients.

Keywords: Perspective, Red cell, alloimmunization

Introduction

Red blood cell (RBC) alloimmunization, defined as the development of antibodies against foreign antigens on RBCs, can arise following exposure via transfusion or pregnancy. An antibody is produced when the body encounters red blood cells that differ from the healthy tissues in our body. Red blood cell alloimmunization occurs when a pregnant woman's body creates antibodies against the red blood cells of her unborn child. The most common recipients of RBC alloimmunization are those who need multiple transfusions, such as individuals with sickle cell disease or chronic anemia [1].

It is crucial to recognize that the recipient may develop alloimmunization as a direct consequence of the blood transfusion, which is categorized as an unfavorable reaction. Following a sensitizing event, like a transfusion, red cell alloimmunization manifests as the production of alloantibodies. Because to transfusion record fragmentation, missed alloantibody detection, and antibody evanescence, it is anticipated that only 30% of induced RBC alloantibody generation is recognized. Rh, Kell, Duffy, and Kidd are the blood groups most frequently implicated. The most common recipients of RBC alloimmunization are those who need multiple transfusions, such as patients with sickle cell disease or chronic anemia [2].

Medical professionals who treat women who are capable of bearing children face the challenge of alloimmunization to red blood cell (RBC) antigens [3]. During pregnancy or transfusion, exposure to non-self RBC antigens can result in the development of antibodies. If a subsequent fetus carries that antigen, maternal antibodies may attack the fetal red blood cells, causing red cell destruction and hemolytic disease of the fetus and newborn (HDFN), which in the worst cases can cause intrauterine fetal death from high output cardiac failure, effusions, and ascites, a condition known as hydrops fetalis [4].

The formation of antibodies against foreign red blood cell antigens, or red cell alloimmunization, is mostly brought on by exposure to these antigens during pregnancy or blood transfusion. An immunological reaction may be triggered during transfusions if the recipient's and donor's blood types are not compatible. Fetal red blood cells have the potential to cross

the placenta during pregnancy and expose the mother to foreign antigens, especially in cases when Rh-negative women are carrying Rh-positive children [5].

Alloimmunization occurs when the immune system recognizes an antigen, which is a protein or other molecule on a cell's surface, as foreign. When these antigens are recognized, white blood cells create antibodies, signaling the immune system to attack the foreign cell that contains the antigen [6]. This process, known as immunization, typically protects the body from dangerous organisms such as viruses or bacteria. However, when it develops in reaction to another human's antigens (alloimmunization), it might lead to major consequences [7].

The most common alloimmunization reactions involve red blood cells (RBCs). Individuals have different blood types, which are defined by the antigens found on red blood cells. These blood types are classified according to the ABO and Rh systems. The ABO system has four blood groups: A, B, AB, and O, which reflect the presence or lack of A and B antigens on red blood cells. Meanwhile, the Rh system contains around 50 antigens on the membranes of RBC. The D antigen is the most widely tested antigen in the Rh system. Rh negative (Rh-) refers to RBCs that lack the D antigen, whereas Rh positive (Rh+) refers to those that do. A blood type may be based on both the ABO and Rh systems. For example, AB+ would show the presence of A, B, and D antigens on a person's red blood cells. Adults who do not have the specific antigen on their RBCs frequently generate antibodies to A and B antigens in their plasma [8].

This occurs because humans are frequently exposed to bacterial antigens that are identical to those found in red blood cells. In contrast, Rh antigen exposure is typically limited to pregnancy or blood transfusions, which can result in alloimmunization. Alloimmunization can develop during pregnancy if the pregnant woman and her fetus have different blood types. There are two types of alloimmunization during pregnancy: ABO incompatibility and Rh incompatibility [9].

ABO incompatibility occurs when the mother's RBCs lack the A or B antigen, whereas the fetal blood cells contain that antigen. This occurs when the fetus acquires their father's blood type. This is unlikely to pose significant issues for either the baby or the mother because the mother's IgM antibodies cannot pass the placenta, which gives nourishment to the fetus and separates the fetal and maternal blood. As a result, the IgM antibodies will defend the mother while not injuring the infant. Rh incompatibility occurs when the mother is Rh- and the fetus is Rh+. When a Rh- mother is exposed to a Rh+ baby after delivery, her immune system produces IgG antibodies. During a second pregnancy with a Rh+ fetus, the mother's existing IgG antibodies can cross the placenta and target the fetuses' RBCs, causing them to burst, a process known as hemolysis [10]. If left untreated, Rh incompatibility can cause fetal and neonatal hemolytic disease (HDFN). The effect of hemolysis on the fetus depends on the quantity of antibodies in the mother's blood. When the mother has only a few antibodies, the infant may suffer moderate anemia that might linger for 2-3 months after birth. In severe situations, however, hemolysis can lead to a life-threatening illness known as hydrops fetalis, which causes severe swelling in the fetus. After birth, it may cause severe anemia or jaundice. Infants with severe anemia may exhibit pale complexion, low energy levels, or congestive heart failure. If a first pregnancy is compromised by alloimmunization, subsequent pregnancies are more likely to develop serious disease early in the pregnancy [11].

The process of alloimmunization in blood transfusions is comparable to what occurs during pregnancy. Individuals who require frequent blood transfusions (e.g., sickle cell anemia, thalassemia) are more likely to experience alloimmunization reactions [12].

Alloimmunization during blood transfusions can cause an acute, rapid, or delayed hemolytic transfusion reaction with a variety of symptoms, including fever, chills, backaches or headaches, shortness of breath, and elevated heart rate [13]. Transfusion responses can cause serious clinical complications, such as the formation of blood clots throughout the body (disseminated intravascular coagulation) and acute renal failure. Although ABO incompatibility causes the most severe symptoms, Rh incompatibility is more common [14]. Refractoriness, a condition in which transfused platelets are quickly destroyed and do not raise the platelet count, can occur in certain people, especially those who need frequent platelet transfusions [15].

Alloimmunization diagnosis

Getting a medical history and any symptoms or indicators is the first step in diagnosing alloimmunization. Depending on the status of the individual, there are then a number of diagnostic tests for suspected alloimmunization [16].

A maternal antibody screening may be done to find out if the mother has produced antibodies to the fetus' antigens, and blood tests are performed to ascertain the mother's Rh status during pregnancy. Serial ultrasounds and Doppler investigations can be used to diagnose related diseases such fetal anemia or hydrops fetalis when alloimmunization is suspected. Newborns whose mothers have received confirmed alloimmunization will be evaluated for anemia symptoms after birth. To precisely identify which antibodies are present, testing may be performed on neonates who exhibit symptoms or whose mother has a distinct blood type [17].

Blood transfusion recipients will be watched for the symptoms of an acute hemolytic transfusion reaction, which includes chills and fever. An antibody screening may be performed to diagnose alloimmunization if they exhibit symptoms and indicators of a transfusion reaction [18].

Treatment of alloimmunization

The reason and intensity of the reaction will determine how the alloimmunization is treated. For instance, intrauterine transfusions in which red blood cells compatible with the mother's antibodies are given directly into the fetus via the umbilical vein and careful monitoring may be necessary for fetal anemia. Early delivery may be required if fetal anemia or hydrops fetalis persists in spite of treatment; the newborn will frequently need exchange transfusions after this. In order to do this, little portions of the newborn's blood must be extracted and replaced with donor blood.

A blood sample should be taken to check for a fresh blood donor match, and the transfusion should be halted right away if alloimmunization happens during the procedure. The goal of treatment is to stabilize the patient and provide any supportive care they may require, such as extra oxygen, intravenous fluids, and vasopressors for hypotension [19].

Alloimmunization prevention

Anti-D immune globulin (RhoGAM) can be administered to Rh-negative pregnant women at 28 weeks gestation, within 72 hours of delivery, and following any event that may result in fetal-maternal blood mixing (such as amniocentesis, miscarriage, or trauma) in order to prevent the formation of anti-Rh antibodies.

During a transfusion, a number of screening tests should be carried out to avoid alloimmunization. During the first screening, the person's blood type and antibody levels will be determined. Additional testing may be carried out to identify the precise antibodies present in the person's blood if the antibody screen comes up positive. The recipient's blood will then be matched to that of a donor who has the same blood type but lacks the particular antigens against which the recipient has antibodies. The risk of alloimmunization during blood transfusions is reduced by this screening procedure [20].

Conclusion

Alloimmunization is a condition in which the body's immune system generates antibodies to antigens from another person. The body can come into touch with foreign antigens through a variety of methods, including pregnancy, blood transfusions, and organ transplants. When the body is exposed to red blood cells that differ from the healthy tissues, it produces an antibody.

If a pregnant woman's body generates antibodies against her baby's red blood cells, this is known as red blood cell alloimmunity. Red blood cell alloimmunization can harm the fetus, causing severe anemia, low oxygen levels, fluid buildup (hydrops fetalis), and heart failure. All pregnant women are routinely checked for red blood cell alloimmunization as part of their prenatal care. Better identification and treatment of this disease has increased newborn survival.

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CITATION

Chinedu-Madu J.U. (2025). Perspective of Red blood cell (RBC) alloimmunization. In *Global Journal of Research in Medical Sciences* (Vol. 5, Number 3, pp. 9–12). <https://doi.org/10.5281/zenodo.15331058>