Review Article

Blood Transfusion: Benefits, Risks, and Alternatives

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How to cite this article: Aloy-Amadi Oluchi C., Akogu Okechukwu, Aloy-Amadi Winifred U. Blood Transfusion: Benefits, Risks, and Alternatives. International Journal of Contemporary Surgery / Vol 13 No. 2, July - December 2025

Abstract

Blood transfusion is a vital medical procedure used to restore lost blood and improve oxygen supply in patients. It plays a life-saving role in surgeries, trauma cases, and conditions like anemia and cancer. While transfusions can be highly beneficial, they are not without risks. Complications such as allergic reactions, infections, and iron overload may occur. Fortunately, with careful practices and growing alternatives like autologous donation and artificial blood, the safety of transfusion is steadily improving. This article provides an easy-to-understand but in-depth look at the uses, risks, preventive strategies, and substitutes for blood transfusion, based on the latest research and expert guidelines.

Keywords: Blood transfusion, Anemia, Blood safety, Transfusion reactions, Blood alternatives, Patient blood management.

Abstract

Blood transfusion is a vital medical procedure used to restore lost blood and improve oxygen supply in patients. It plays a life-saving role in surgeries, trauma cases, obstetric emergencies, and conditions like anemia and cancer. While transfusions can be highly beneficial, they are not without risks. Complications such as allergic reactions, infections, circulatory overload, and iron overload may occur. Fortunately, with careful practices and growing alternatives like autologous donation, intraoperative blood salvage, and artificial blood substitutes, the safety and sustainability of transfusion are steadily improving. This article provides an in-depth review of the uses, risks, preventive strategies, and substitutes for blood transfusion, based on the latest research, expert guidelines, and evolving practices in transfusion medicine.

Keywords: Blood transfusion, Anemia, Blood safety, Transfusion reactions, Blood alternatives, Patient blood management, Hemovigilance.

Introduction

Blood transfusion simply means giving someone else's blood or specific blood components (like red cells, platelets, or plasma) to a patient who needs it. It is a routine and often essential procedure in hospitals across the world. Patients may need transfusions due to surgery, serious injuries, obstetric complications, blood disorders like anemia, sickle cell disease, or thalassemia, or conditions such as cancer[1].

Globally, blood transfusion is a common medical intervention. According to the World Health Organization (WHO), over 100 million blood donations are collected every year[2]. Yet, transfusion is not a "one-size-fits-all" treatment. While

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Submission: September 5, 2025 **Revision:** October 29, 2025 **Published date:** November 4, 2025

transfusions can be lifesaving, they also carry risks and must be used judiciously. The concept of Patient Blood Management (PBM) is increasingly promoted worldwide to reduce unnecessary transfusions and improve patient outcomes[3].

In recent years, the medical community has placed increasing importance on rational blood use, mainly due to growing demand, limited supply, and the potential for adverse events. This review is essential to help healthcare professionals especially in low- and middle-income settingsstay informed about transfusion practices, safety measures, and technological advancements in transfusion medicine.

Benefits of Blood Transfusion

Replacing Lost Blood Volume

One of the most important uses of transfusion is replacing blood lost due to surgery, trauma, obstetric hemorrhage, or internal bleeding. Losing too much blood can lead to hypovolemic shock, multi-organ failure, and even death. Transfusion stabilizes the patient, restores circulatory volume, and buys time for definitive treatment[4, 5].

Improving Oxygen Supply

Red blood cells (RBCs) carry oxygen through hemoglobin molecules. Severe anemia or acute blood loss reduces oxygen delivery, leading to hypoxia, tissue damage, and fatigue. Transfusing red cells increases hemoglobin concentration, improving oxygen delivery and tissue perfusion. This is particularly vital for patients with chronic anemia, heart disease, or those undergoing chemotherapy[6, 7].

Helping with Clotting Problems

Some patients develop clotting problems due to diseases, medications (like anticoagulants), or massive bleeding. In such cases, transfusion of platelets or plasma (rich in clotting factors) restores hemostasis. This is essential in patients with thrombocytopenia, liver disease, disseminated intravascular coagulation (DIC), or inherited bleeding disorders such as hemophilia[8, 9].

Supporting Cancer Patients

Cancer treatments like chemotherapy and radiotherapy often suppress bone marrow function, reducing blood cell production. This can result in anemia, leukopenia, and thrombocytopenia. Transfusions of RBCs and platelets help restore blood counts, improve quality of life, reduce fatigue, and prevent bleeding episodes in cancer patients[10, 11].

Helping During and After Surgery

Certain surgeries particularly cardiovascular, orthopedic, or abdominal operationsinvolve significant blood loss. Blood transfusions maintain patient stability, support oxygen delivery, and reduce surgical complications. Preoperative and intraoperative blood management reduces the need for excessive transfusion while ensuring patient safety[12, 13].

Obstetric Emergencies

Postpartum hemorrhage (PPH) remains one of the leading causes of maternal mortality globally. Prompt blood transfusion in women experiencing severe bleeding during childbirth is crucial to saving lives, especially in resource-limited settings[14, 15].

Managing Chronic Conditions

Patients with chronic conditions such as thalassemia, sickle cell anemia, or aplastic anemia often require regular transfusions. For such patients, transfusion therapy prevents complications like severe anemia, organ damage, and stroke, thereby improving survival and quality of life[16].

Risks and Complications

Although transfusion is generally safe, complications can occur. Modern screening and protocols have reduced many risks, but vigilance is always necessary.

Allergic Reactions

Allergic reactions to donor plasma proteins can cause itching, rash, or urticaria. Severe cases

may progress to bronchospasm, hypotension, or anaphylaxis. Most mild reactions resolve with antihistamines, but severe cases require immediate intervention with epinephrine[17].

Febrile Non-Hemolytic Transfusion Reactions (FNHTR)

FNHTR occurs when the recipient's immune system reacts to donor leukocytes or cytokines. Symptoms include fever, chills, and discomfort. While usually not life-threatening, FNHTR is unpleasant. Leukoreduction (removal of white cells) significantly reduces this risk[18].

Hemolytic Transfusion Reactions

This serious reaction occurs when incompatible donor RBCs are destroyed by the recipient's immune system. Acute hemolytic reactions result from ABO incompatibility and may cause fever, chest pain, back pain, hypotension, hemoglobinuria, and renal failure. Proper crossmatching and typing prevent most cases[19].

TRALI (Transfusion-Related Acute Lung Injury)

TRALI is a life-threatening complication caused by donor antibodies reacting with recipient leukocytes in the lungs, leading to pulmonary edema. It presents with acute respiratory distress within 6 hours of transfusion and is one of the leading causes of transfusion-related mortality[20, 21].

TACO (Transfusion-Associated Circulatory Overload)

Rapid or excessive transfusion, especially in children, elderly, or patients with cardiac dysfunction, may cause circulatory overload. Symptoms include hypertension,dyspnea, and pulmonary edema. Preventive strategies include careful monitoring and slower transfusion rates[22].

Infections

Although modern testing has drastically reduced transfusion-transmitted infections (TTIs), risks remain, especially in low-resource countries. Viruses such as HIV, hepatitis B, hepatitis C, HTLV, syphilis, malaria, and bacterial contamination from poor storage conditions can be transmitted[23, 24].

Iron Overload

Patients requiring chronic transfusions (e.g., thalassemia, sickle cell anemia) may develop iron overload, as each unit of blood contains 200–250 mg of iron. Excess iron deposits in the heart, liver, and pancreas, causing organ damage. Chelation therapy with agents like deferoxamine or deferasirox is required[25].

Immune Modulation

Transfusion may cause immune suppression, increasing infection risk and possibly affecting cancer recurrence rates. This phenomenon, termed transfusion-related immunomodulation (TRIM), remains an active area of research[26].

How Risks Are Reduced

Modern transfusion medicine uses multiple safeguards to minimize risks.

Careful Donor Screening

Donors are screened through questionnaires, interviews, and laboratory testing. Blood is tested for ABO, Rh, syphilis, HIV, HBV, HCV, malaria, and sometimes Zika or West Nile virus in endemic regions[27].

Leukoreduction

Widespread use of leukoreduced blood has decreased febrile reactions, CMV transmission, and alloimmunization. Many countries mandate leukoreduction for all donated blood[28].

Blood Washing and Irradiation

Washing blood removes plasma proteins, reducing allergic reactions. Irradiation of cellular blood products prevents transfusion-associated graft-versus-host disease (TA-GVHD) in immuno compromised patients[29].

Hemovigilance Programs

Hemovigilance involves systematic monitoring of transfusion events, including adverse reactions. Such programs improve safety by identifying risks, promoting quality assurance, and training healthcare workers[30].

Patient Blood Management (PBM)

PBM emphasizes optimizing a patient's own blood to minimize transfusion needs. Strategies include preoperative anemia correction, antifibrinolytic use (e.g., tranexamic acid), and minimally invasive surgery[31].

Alternatives to Blood Transfusion

Doctors can often manage patients without donor blood by using innovative strategies.

Autologous Donation

Patients undergoing elective surgeries may donate their own blood beforehand. This eliminates alloimmunization and infectious risks[32].

Blood Conservation Techniques

Methods like acute normovolemic hemodilution (ANH) and intraoperative cell salvage allow temporary collection and reinfusion of a patient's own blood during surgery, reducing donor blood need[33].

Medications

Erythropoietin (EPO): Stimulates RBC production, useful in chronic kidney disease or chemotherapy-induced anemia.

Iron, vitamin B12, folic acid supplements: Correct nutritional anemias.

Tranexamic acid: An antifibrinolytic agent reducing surgical blood loss.

Desmopressin: Enhances platelet function in uremic patients[34].

Artificial Blood

Research is ongoing into synthetic substitutes like perfluorocarbons (PFCs) and hemoglobin-based oxygen carriers (HBOCs). Though not yet mainstream, they hold promise for trauma care and battlefield medicine[35, 36].

Conclusion

Blood transfusion remains one of modern medicine's greatest achievements. It saves lives daily in trauma, surgery, obstetrics, and chronic disease management. However, it carries risks, ranging from mild allergic reactions to life-threatening TRALI or iron overload. Advances such as leukoreduction, pathogen screening, PBM, and hemovigilance have improved safety significantly. Still, transfusion should be carefully considered, balancing risks against benefits. Alternatives, including autologous donation, intraoperative salvage, and emerging artificial blood products offer valuable adjuncts. Ultimately, transfusion decisions must be individualized based on patient needs, evidence-based guidelines, and available resources.

Significance of The Review

This review is particularly relevant in today's healthcare landscape. With rising demand for safe and sustainable transfusion services, especially in low- and middle-income countries, it is crucial for clinicians, policymakers, and students to understand both traditional and modern approaches. This review bridges knowledge gaps, emphasizes patient safety, and highlights future directions in transfusion medicine.

Conflicting Interest: There is no conflict of interest.

Funding: The research study was solely funded by the authors.

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