

BLOOD AND ITS COMPONENTS

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Abstract- The whole blood which is a mixture of cells, colloids and crystalloids can be separated into different blood components namely packed red blood cell (PRBC) concentrate, platelet concentrate, fresh frozen plasma and cryoprecipitate. Each blood component is used for a different indication; thus the component separation has maximized the utility of one whole blood unit. Different components need different storage conditions and temperature requirements for therapeutic efficacy. A variety of equipments to maintain suitable ambient conditions during storage and transportation are in vogue. The blood components being foreign to a patient may produce adverse effects that may range from mild allergic manifestations to fatal reactions. Such reactions are usually caused by plasma proteins, leucocytes, red cell antigens, plasma and other pathogens. To avoid and reduce such complications, blood products are modified as leukoreduced products, irradiated products, volume reduced products, saline washed products and pathogen inactivated products. The maintenance of blood inventory forms a major concern of blood banking particularly of rare blood groups routinely and common blood groups during disasters. PRBCs can be stored for years using cryopreservation techniques. New researches in red cell cultures and blood substitutes herald new era in blood banking.

Keywords: Blood transfusion, blood components, hemoglobin, common blood test diseases of blood.

INTRODUCTION

Blood is a lifesaving liquid organ. Whole blood is a mixture of cellular elements, colloids and crystalloids. As different blood components have different relative density, sediment rate and size they can be separated when centrifugal force is applied. In increasing order, the specific gravity of blood components is plasma, platelets, leucocytes (Buffy Coat [BC]) and packed red blood cells (PRBCs). Functional efficiency of each component is dependent on appropriate processing and proper storage. To utilise one blood unit appropriately and rationally, component therapy is to be adapted universally ⁽¹⁾.

PROPERTIES OF BLOOD :

Blood is red in colour. Arterial blood is scarlet red because it contains more oxygen and venous blood is purple red because of more carbon dioxide. Volume: Average volume of blood in a normal adult is 5 L. In a newborn baby, the volume is 450 ml. It increases during growth and reaches 5 L at the time of puberty. In females, it is slightly less and is about 4.5 L. It is about 8% of the body weight in a normal young healthy adult, weighing about 70 kg. Reaction and pH: Blood is slightly alkaline and its pH in normal conditions is 7.4. Specific gravity: Specific gravity of total blood: 1.052 to 1.061 Specific gravity blood cells: 1.092 to 1.101 Specific gravity of plasma: 1.022 to 1.026 5. Viscosity: Blood is five times more viscous than water. It is mainly due to red blood cells and plasma proteins.

FUNCTIONS OF BLOOD:

Nutritive function Nutritive substances like glucose, amino acids, lipids and vitamins derived from digested food are absorbed from gastrointestinal tract and carried by blood to different parts of the body for growth and production of energy. **Respiratory function** Transport of respiratory gases (O₂ & CO₂) is done by the blood. **Excretory function** Waste products formed in the tissues during various metabolic activities are removed by blood which carried to the excretory organs like kidney, skin, liver, etc. for excretion. **Transport of hormones and enzymes** Hormones which are secreted by ductless (endocrine) glands are released directly into the blood. **Regulation of water balance** Water content of the blood is freely interchangeable with interstitial fluid. This helps in the regulation of water content of the body. **Regulation of acid-base balance.** Plasma proteins and hemoglobin acts as buffers and help in the regulation of acid-base balance. **Regulation of body temperature** The high specific heat of blood, it is responsible for maintaining the thermoregulatory mechanism in the body. **Storage function** Water and some important substances like proteins, glucose, sodium and potassium are constantly required by the tissues. These substances are taken from blood during the conditions like starvation, fluid loss, electrolyte loss, etc. **Defensive function** Blood plays an important role in the defense of the body. The white blood cells are responsible for this function. Neutrophils and monocytes engulf the bacteria by phagocytosis. Lymphocytes are involved in development of immunity. Eosinophils are responsible for detoxification, disintegration and removal of foreign proteins.

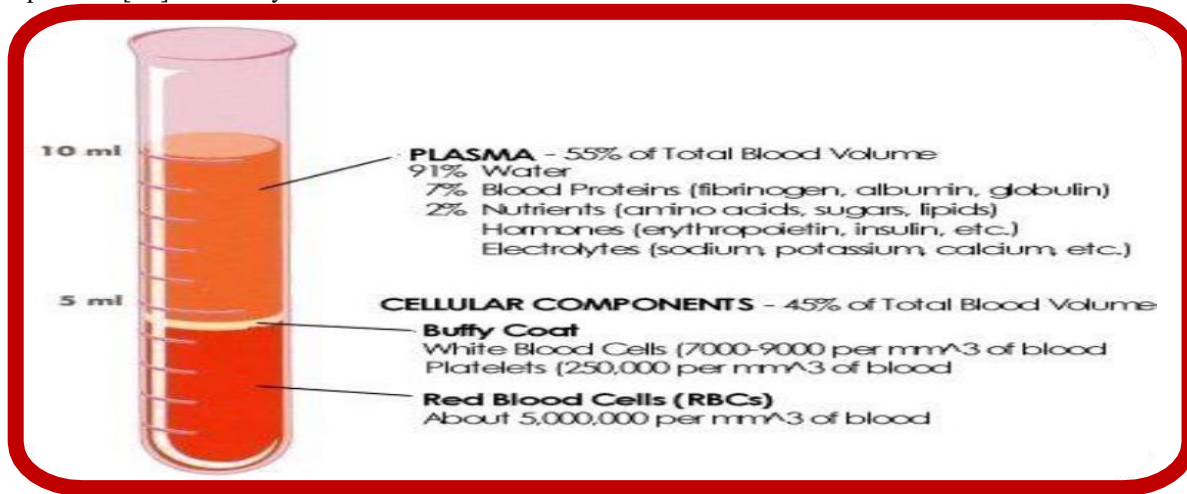
BLOOD COMPONENTS

• Blood is composed from 2 fractions:

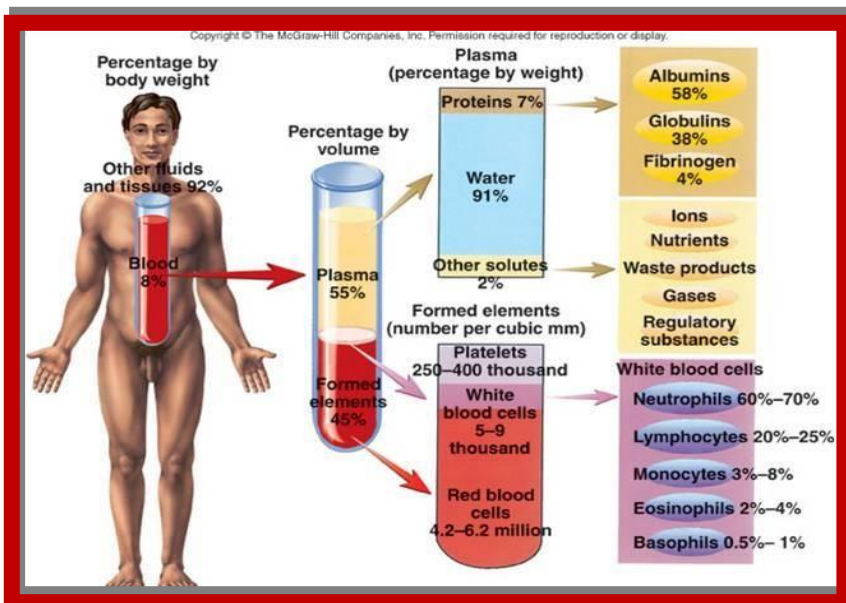
1. Plasma
2. Nonliving extracellular matrix composes about 55% of total blood volume.

2.FORMED ELEMENTS (CELLULAR CONTENT OF BLOOD) • Three types of cells are present in the blood:

1. Red blood cells (RBC) or erythrocytes
2. white blood cells[WBC]or leukocytes
- 3.platelets [or]thrombocytes



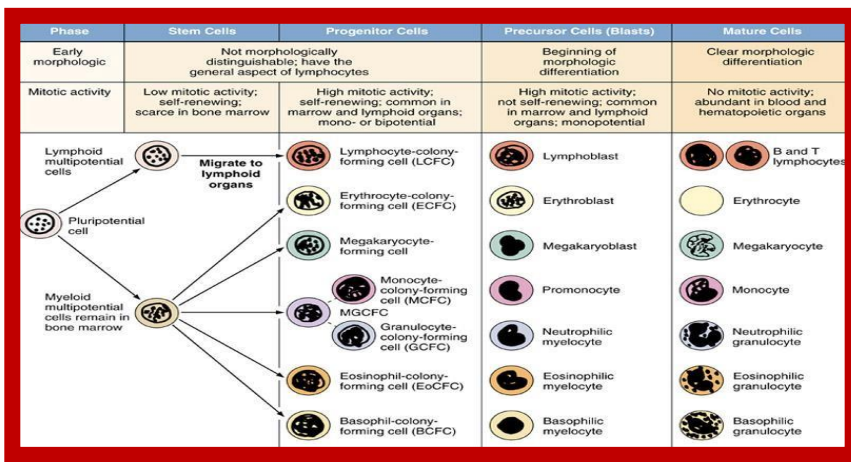
Hematocrit tube with blood after centerfugation Plasma forms the supernatant, buffy coat forms the middle layer and thered blood cells form the sediment



Source of Blood Cells

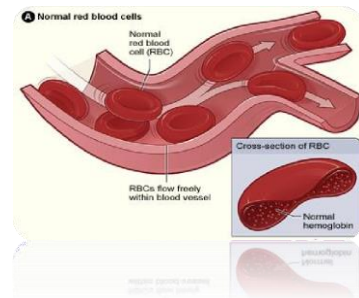
- 1.Mature blood cells have a relatively short life spine.
- 2.Blood cells are synthesised mainly in the red bone marrow.
- 3.Some lymphocytes, additionally are produced in lymphoid tissue.

The organ or system responsible for synthesis blood cells are called hematopoietic system and the process of blood cell formation is called hematopoiesis.



Erythrocytes = Red Blood Cells

1. Red blood cells are biconcave disc ,they have no nucleus and cytoplasmic organelles.
2. Contain red coloured protein called hemoglobin
3. There main function is in gas transport mainly of O2 but they also carry someCO2.
4. Human erythrocytes are 7.5 µm in diameter, 2.6 µm thick at the rim and 0.8 µm thick inthe center.
5. The biconcave shape increases their surface area for gas exchange, and the thinness ofthe central portion allows fast entry and exit of gases.
6. The cells are flexible so they can squeeze through narrow capillaries.
7. The normal concentration of erythrocytes in blood is approximately 3.9- 5.5 million per microliter in women and 4.1-6 million permicroliter in men.

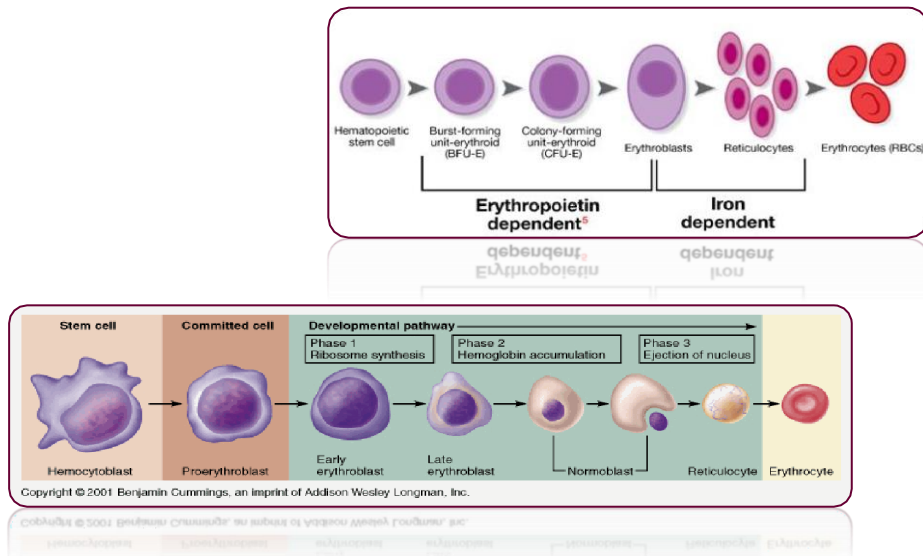


Biconcave shape of RBC

Life Span and Formation of Red Blood Cells

1. Erythrocytes are produced in red bone marrow (in the ends of longbones and in flat and irregular bones).
2. They pass through several stages of development before entering the blood.
3. Their life span in circulation is about 120 days.
4. The process of RBC development from stem cells takes about 7 days and iscalled erythropoiesis.
5. The immature cells are released into the blood stream as reticulocytes and then mature into erythrocytes over 1-2 days within circulation. During this time, they lose their nucleus and therefore become incapable of division.
6. The hormone erythropoietin and substances such as iron, folic acid, and vitamin B12 are essential for the production of erythrocytes.
7. Erythropoietin hormone is a glycoprotein hormone produced in the kidneys and stimulates the production of globin (the protein component of Hb), enhancesthe release reticulocytes in the circulation and enhances reticulocytesmaturation to mature RBC.

Erythropoiesis



BLOOD AND ITS COMPONENTS

Physiological Factors influencing RBC number

1. RBC count is very high at birth (8-10 million/mm³).
2. The count is higher in children than in adults.
3. RBC count is raised at high altitude, in warm temperature, during excitement in women RBC count is relatively low during pregnancy. A fall in RBC count is seen at low altitude.

Function: They are playing a vital role in transport of respiratory gases (oxygen and carbon dioxide) due to the presence of hemoglobin as a major constituent of red blood cell. Buffering Action in Blood: hemoglobin functions as a good buffer. By this action, it regulates the hydrogen ion concentration and thereby plays a role in the maintenance of acid base balance. In Blood Group Determination: RBCs carry the blood group antigens like A antigen, B antigen and Rh factor. This helps in determination of blood group and enables to prevent reactions due to incompatible blood transfusion.

Hemoglobin (Hb)

1. Hb is the most important constituent of red blood cells. It is responsible for transport of O₂ from lungs to tissues and CO₂ from tissues to lungs.
2. The normal value in a normal male adult is **13-18 g/100ml** and in female is 11.5-16.5g/ml
3. Molecules of hemoglobin are large and complex. They are **heme** and **globin**.
Heme is made up of **iron** (in ferrous form) and **porphyrin**.
4. **Globin** is a protein that has **4 polypeptide chains** (2 α and 2 β).
5. Each unit of Hb contains **4 units of heme** that are united together by the α and β chains of globin.
6. Each unit of heme can combine with one molecule of O₂. So one molecule of Hb can carry **4 molecules of O₂**.
7. Each RBC carries **about 280 million Hb molecules**, therefore each RBC has the ability to carry **over a billion O₂ molecules**.
8. Hb with O₂ is called oxyhemoglobin and Hb without O₂ called deoxyhemoglobin.

Types of Normal Hb

1. **Fetal hemoglobin Hb F** (α_2 and γ_2): presents in the fetus during the last seven months of development in the uterus. and replaced by adult Hb within 6 months after birth.
2. **Adult hemoglobin Hb (Hb A)** consists of :
 - a. HbA ($\alpha_2 \beta_2$) 95%
 - i. Hb A₂ ($\alpha_2 \delta_2$) 1.5- 3%
 - b. Very small amounts of Hb F ($\alpha_2 \gamma_2$)

Blood Groups

1. The plasma membrane of erythrocytes are composed of lipids and proteins.
2. Several types of proteins are present including A, B proteins (antigens) and (D) factor responsible for person's blood group.
3. Individuals make antibodies to these antigens but not to own type of antigen.
4. Persons of blood group A have antigen of type A on their red blood cells. Their serum contains antibodies of type B.
5. Persons of blood group B have antigen of B on their red blood cells. Their serum contains antibodies of type A.
6. Persons of blood group AB have antigens of both types A and B. they do not have type A or type B antibodies.

7. Persons of blood group O have neither A nor B. antibodies of both types A and B are present.
8. Rh factor or antigen (Rhesus factor), about 85% of people have this antigen on cell membrane of RBC.

LEUCOCYTES = WHITE BLOOD CELLS

1. **Granulocytes** which contain granules in their cytoplasm and they
 2. *Neutrophils, eosinophils and basophils.*
3. **Agranulocytes**
 - *Monocytes and lymphocytes.*
4. There are about 7500 μl (range 5000-10000 μl).
5. **Neutrophils** represent **60-70%** of total WBC. And about **20-30% lymphocytes**. While **eosinophils** are about **3%**, **basophils 1%** and **monocytes about 5%**.

6. The 5 types of human leukocytes. Neutrophils, eosinophils, and basophils have granules that stain specifically with certain dyes and are called granulocytes. Lymphocytes and monocytes are agranulocytes; they may show azurophilic granules, which are also present in other leukocytes

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Thrombocytes = platelets

1. Blood platelets are non-nucleated disc like cell fragments 2-4 μm in diameter.
2. Platelets are not true cells. They originate from fragments of megakaryocyte cytoplasm that reside in the red bone marrow.
3. Each platelet has a peripheral light blue stain transparent zone the hyalomere and a central zone containing granules called the granulomere.
4. Platelets granules contain calcium ions, ADP, ATP, serotonin, pyrophosphate, hydrolytic enzymes, P- selectin, fibrinogen, platelet-derived growth factor, coagulation factor V and XIII and other substances.
5. Platelets are very sticky so appear under light microscope as clumps of cells.
6. Platelets promote blood clotting and help repair gaps in the walls of blood vessels, preventing loss of blood.
7. Normal platelets counts range from 200,000- 400,000 per microliter of blood.
8. Thrombopoietin released by kidneys has ability to stimulate platelets synthesis.
9. Platelets have a life span of about 10 days.

Common blood tests

Test	Uses
CBC, which includes: <ul style="list-style-type: none"> • White blood cell count (WBC) • Red blood cell count (RBC) • Platelet count • Hematocrit red blood cell volume (hct) • Hemoglobin (Hgb) concentration. Hemoglobin is the oxygen-carrying pigment in red blood cells. <ul style="list-style-type: none"> • Differential blood count 	To help diagnose anemia and other blood disorders and certain cancers of the blood; to monitor blood loss and infection; or to monitor response to cancer therapy, such as chemotherapy and radiation
Platelet count	To diagnose and monitor bleeding and clotting disorders
Prothrombin time (PT) and partial thromboplastin time (PTT)	To evaluate bleeding and clotting disorders and to monitor anticoagulation (anticoagulation) therapies

Blood transfusion

blood transfusion involves running pretransfusion testing for compatibility between recipient antibodies and donor red blood cells. This involves obtaining a sample of the recipient's blood to send for a type and screen. The type and screen test verifies the recipient's blood type and also determines if the recipient has any "unexpected" (non-ABO) antibodies that might cause a reaction. There are multiple methods for running this screen. If the screen is negative, it is very unlikely there will be a reaction. Obtaining blood for the patient should be done rapidly if required. If the screen is positive, many blood banks will crossmatch and hold two units of blood for the patient in case they need a transfusion. Another prerequisite to blood transfusion is to take consent from the patient if possible.⁽²⁾

The following is the list of important steps to follow before proceeding with blood transfusion:

Find Current Type and Crossmatch

- Take a blood sample, which lasts up to 72 hours
- Send the sample to the blood bank
- Ensure that the blood sample has the correct labeling with the date and timing
- Wait for the blood bank to crossmatch and prepare the needed units

Obtain Informed Consent and Health History

- Discuss the procedure with the patient
- Confirm the past medical history and any allergies
- The supervising provider should have obtained signed consent from the patient

Obtain Large-bore Intravenous Access

- This is 18 gauge or larger IV access
- Each unit should be transfused within 2-4 hours
- A second IV access should be secured in case the patient needs additional IV medications
- Normal saline is the only fluid that can be administered with blood products

Assemble Supplies

- Y tubing with an in-line filter
- 0.9% NaCl solution
- Blood warmer

Obtain Baseline Vital Signs

- These include heart rate, temperature, blood pressure, pulse oximeter, and respiratory rate
- Respiratory sounds and urine output should also be documented
- Notify the provider if the temperature is more than 100 F

Obtain Blood from the Blood Bank

- Once the blood bank notifies that the blood is ready, its delivery from the blood bank should be ensured
- Packed red blood cells can only be given one unit at a time
- Once the blood has been released for the patient, there are 20-30 minutes to begin the transfusion and up to four hours to complete it.

Technique or Treatment

Here are some of the general steps providers should follow when carrying out a blood transfusion:

- Verify Blood Product
- Relay the features of a transfusion reaction to the patient. The patient should inform the nursing staff during the transfusion if these appear.
- Baseline vital signs, lung sounds, urine output, and skin color
- Prepare the Y tubing with 0.9% NaCl and have the blood unit ready in an infusion pump
- The blood should be run slowly for the first fifteen minutes, for instance, 2 ml/min or 120 ml/hr
- Staff should be supervising the patient for the first fifteen minutes as this is when most transfusion reactions happen
- The rate of transfusion can be increased after this period if the patient is stable and does not display any signs of a transfusion reaction
- Document vital signs after fifteen minutes, then every hour, and finally, at the end of the transfusion
- During the transfusion, look for any signs of transfusion reactions
- If a reaction is suspected, stop the transfusion immediately
- Disconnect the blood tubing from the patient
- Inform the provider, stay with the patient and assess the status
- Document everything
- After the transfusion, flush Y tubing with normal saline and dispose of used Y tubing in the biohazard bin
- Obtain post-transfusion vital signs
- After the procedure, some patients could experience soreness at the puncture site, but this should dissipate quickly.

Adverse Event and Approximate Risk Per Unit Transfusion of RBC

- Febrile reaction: 1:60
- Transfusion-associated circulatory overload: 1:100
- Allergic reaction: 1:250
- TRALI: 1:12,000
- Hepatitis C infection: 1:1,149,000
- Human immunodeficiency virus infection: 1:1,467,000
- Fatal hemolysis: 1:1,972,000

Febrile Reactions⁽³⁾

Transfusing with leukocyte-reduced blood products, which most blood products in the United States are, may help reduce febrile reactions. If this occurs, the transfusion should be halted, and the patient evaluated, as a hemolytic reaction can initially appear similar and consider performing a hemolytic or infectious workup. The treatment is with acetaminophen and, if needed,

diphenhydramine for symptomatic control. After treatment and exclusion of other causes, the transfusion can be resumed at a slower rate.

Transfusion-associated Circulatory Overload ⁽⁴⁾

It is characterized by respiratory distress secondary to cardiogenic pulmonary edema. This reaction is most common in patients already in a fluid-overloaded state, such as congestive heart failure or acute renal failure. Diagnosis is based on symptom onset within 6 to 12 hours of receiving a transfusion, clinical evidence of fluid overload, pulmonary edema, elevated brain natriuretic peptide, and response to diuretics.

Preventive efforts and treatment include limiting the number of transfusions to the lowest amount necessary, transfusing over the slowest possible time, and administering diuretics before or between transfusions.

Allergic Reaction ⁽⁵⁾

It often manifests as urticaria and pruritis and occurs in less than 1% of transfusions. More severe symptoms, such as bronchospasm, wheezing, and anaphylaxis, are rare. Allergic reactions may be seen in patients who are IgA deficient, as exposure to IgA in donor products can cause a severe anaphylactoid reaction. This can be avoided by washing the plasma from the cells prior to transfusion. Mild symptoms, such as pruritis and urticaria can be treated with antihistamines. More severe symptoms can be treated with bronchodilators, steroids, and epinephrine.

Transfusion-related Lung Injury (TRALI) ⁽⁶⁾

This is uncommon, occurring in about 1:12,000 transfusions. Patients will develop symptoms within 2 to 4 hours after receiving a transfusion. Patients will develop acute hypoxemic respiratory distress, similar to acute respiratory distress syndrome (ARDS). Patients will have pulmonary edema, normal CVP, without evidence of left heart failure CVP. Diagnosis is made based on a history of recent transfusion, chest x-ray with diffuse patchy infiltrates, and the exclusion of other etiologies. While there is a 10% mortality, the remaining 90% will resolve within 96 hours with supportive care only.

Infections

These are potential complications. However, the risk of infections has decreased due to the screening of potential donors, so hepatitis C and human immunodeficiency virus risk are less than 1 in a million.⁽⁷⁾ Bacterial infection can also occur, but does so rarely, about once in every 250,000 units of red cells transfused.

Fatal Hemolysis

This is extremely rare, occurring only in 1 out of nearly 2 million transfusions. It results from ABO incompatibility, and the recipient's antibodies recognize and induce hemolysis in the donor's transfused cells. Patients will develop an acute onset of fevers and chills, low back pain, flushing, dyspnea as well as becoming tachycardic and going into shock. Treatment is to stop the transfusion, leave the IV in place, intravenous fluids with normal saline, and keep urine output greater than 100 mL/hour, diuretics may also be needed. Cardiorespiratory support may be provided as appropriate. A hemolytic workup should also be performed, including sending the donor blood and tubing and post-transfusion labs (see below for list) from the recipient to the blood bank.

- Retype and crossmatch
- Direct and indirect Coombs tests
- Complete blood count (CBC), creatinine, PT, and PTT (draw from the other arm)
- Peripheral smear
- Haptoglobin, indirect bilirubin, LDH, plasma-free hemoglobin
- Urinalysis for hemoglobin

Electrolyte Abnormalities

They can also occur, although these are rare and more likely associated with large volume transfusion.

- Hypocalcemia can result as citrate, an anticoagulant in blood products, binds with calcium. ⁽⁸⁾
- Hyperkalemia can occur from the release of potassium from cells during storage. Higher risk in neonates and patients with renal insufficiency. ⁽⁹⁾
- Hypokalemia can result as a result of alkalization of the blood as citrate is converted to bicarbonate by the liver in patients with normal hepatic function. ⁽¹⁰⁾

conclusion

blood is a complex mixture of cells and plasma that performs many essential functions in the body. It is important to maintain a healthy blood composition and circulation for optimal health and well-being.

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