Learning about Blood Component Therapy

Find out how blood products are used, and learn about the latest developments in this field.

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BANKED BLOOD COMPONENTS ARE those components of whole blood that are stored and administered in their original biological form; that is, without pharmaceutical alteration. More than 20 million units of banked blood components are transfused annually in the United States. This article will focus on four components—packed red blood cells (PRBCs), platelets, plasma, and cryoprecipitate—that are frequently used to treat trauma, surgical, and cancer patients, as well as other patients who are experiencing a deficiency as a result of physiologic or pathologic disturbances. A fifth product, granulocytes, has practically disappeared from blood bank shelves, but because it still has minimal usefulness, I’ll discuss it briefly.

Banked blood components are obtained, processed, and stored under guidelines from the American Association of Blood Banks and the FDA, and retain all of their biological properties. Adding preservatives and anticoagulants and removing cellular debris (such as leukocytes) extends the shelf life of components but doesn’t alter the biological features. Because the components contain the host’s biological properties, the recipient may develop a reaction to the product.

**Packed red blood cells**

PRBCs are the most frequently used banked blood component. They’re administered to patients with chronic or acute anemia to prevent or reduce the effects of anemia. To safeguard the blood supply, blood banks have developed review boards to assure that the use of red cells is appropriate.

PRBCs have a shelf life of 6 weeks under normal refrigeration. Researchers are looking into ways to increase the shelf life of fresh PRBCs to 11 weeks. With the addition of glycerol, red cells can be frozen and maintained at minus 65º C (minus 85º F) for 10 years or longer. After thawing, cells are deglycerized in a hypertonic saline bath and must be transfused within 24 hours. Frozen cells contain all of the properties of refrigerated cells, but the process of washing may reduce the cellular yield by as much as 10%.

The need for PRBCs continues to grow. Blood banks struggle to meet this need, and researchers are still stymied in their efforts to develop a suitable substitute. For years, perfluorocarbons have been considered as a potential hemoglobin substitute because they have 100 times the oxygen solubility of human blood. However, these products can’t sustain oxygenation for a sufficient length of time to be beneficial in treating chronic or severe anemia.

In 2002, a blood substitute with extended viability was released for use in South Africa. Hemopure, which is derived from bovine hemoglobin, is a chemically stabilized molecule that has the same oxygen-carrying capacity, gram for gram, as human hemoglobin and has a half-life of 24 to 48 hours. Hemopure molecules are much smaller than RBCs, have lower viscosity (resistance to flow) and release oxygen to the tissues more readily than RBCs. As a result, Hemopure may prove to be more useful than human RBCs in some cases of hypotension or in situations where the patient’s vessels are partially occluded. Human testing in the United States started in 2003, but was stopped by the FDA in 2005 when Creutzfeldt-Jakob disease (CJD) was recognized in cattle.

Today the greatest relief for PRBC use is recombinant human erythropoietin therapy. The kidneys produce and release a hormone called erythropoietin, which stimulates the production of RBCs. Recombinant human erythropoietin has been used for years to help boost red cell production in patients with diabetes whose kidneys have failed. In recent years, epoetin has proven beneficial in treating anemia that results from cancer chemotherapy; the drug stimulates bone marrow production of red cells.

Two products, epoetin alfa and darbepoetin alfa, are on the market. Because they’re expensive, their use may be limited, although they’re often covered by insurance. For acute blood loss and most other symptomatic anemias, red cell transfusion remains the treatment of choice. The use of whole blood is generally reserved for autologous transfusions in the form of preoperative donation or cell salvage.

Autologous blood use not only increases patient safety, but also reduces stress on the always-strained blood supply. To date, the use of homologous whole blood is recommended only for patients requiring blood therapy after liver transplant, to reduce the number of donor exposures.

Leukocyte depletion, originally done only at the bedside, is now routinely performed on all processed units of PRBCs. This not only increases the shelf life of the unit, it also decreases the risk of nonhemolytic transfusion reactions—once the most frequent adverse reaction to transfusions.

Irradiated red cells are recommended for patients at risk for graft-versus-host disease (GVHD), a potentially fatal disorder in which donor cells take over the immune system. Irradiated cells have a shelf life of 28 days. However, irradiation can be performed at any time during storage so the normal shelf life may not be compromised.
Platelets reside in the buffy coat portion of centrifuged blood, which appears as a whitish meniscus between the red cells and plasma. After the red cells are expressed from a unit of blood, the plasma is centrifuged a second time to concentrate the platelets further. Originally, platelets were administered as single-donor units; because a therapeutic dose required 6 to 10 units, patients were exposed to multiple donors with each transfusion. Today, platelet concentrates are more commonly used. These are obtained by apheresis or plateletpheresis, a process that returns blood to the donor after the platelets are removed. One unit of apheresis platelets contains a therapeutic dose, and exposes the recipient to only one donor per transfusion. Patients who require frequent transfusions can be matched to a designated donor who may donate as often as every other day to provide 100% of the recipient’s needed platelets.

As with red cells, platelets may be irradiated before transfusion to reduce the risk of GVHD. To reduce the risk of platelet alloimmunization and nonhemolytic febrile reactions, all units of platelets undergo leukocyte filtration (also called leukocyte depletion) to remove most of the white blood cells. Alloimmunization is a condition in which the body’s immune system sensitizes donor platelets, reducing their activity potential so that patients receive little benefit from the transfusion.

The removal of leukocytes before platelet storage has potential ramifications. Leukocytes continue to exert an immunoresponse even during storage. Because RBC products are stored under refrigeration, the risk of bacterial contamination in leukocyte-reduced components is minimal. Platelets, however, are stored at room temperature, and in the absence of leukocytes, provide an optimal medium for bacterial growth. Bacterial contamination is the second most common cause of death related to blood transfusions (after acute hemolytic transfusion reaction), and platelets are the blood component most likely to be contaminated with bacteria.

To reduce the risk of infusing contaminated platelets, a sample from each unit is cultured and incubated until the time of transfusion. If the culture is positive, the unit is pulled and immediately destroyed.

Pharmacologic products haven’t yet supplanted platelet therapy, although a recombinant human thrombopoietin (also called a colony-stimulating factor or growth factor) to enhance platelet production is on the market. This drug stimulates platelet production, similar to the way erythropoietin stimulates red cell production. A recombinant human thrombopoietin is good news for cancer patients whose platelet stores may be depleted from chemotherapy or radiation. The drug can be administered at home as a subcutaneous injection aimed at boosting platelet counts within 7 to 10 days, so cancer therapy can continue with minimal interruption. However, as with recombinant human erythropoietin, recombinant human thrombopoietin is beneficial only when low platelet counts can be anticipated and the patient has adequate time for recovery. Another limiting factor is that recombinant human thrombopoietin therapy is associated with potentially fatal adverse reactions resulting from hepatotoxicity. New recombinant DNA products, now in clinical trials, are demonstrating efficacy in increasing platelet counts when the bone marrow is functioning normally. However, patients with bone marrow suppression aren’t seeing a benefit. Therefore, these drugs may be used to increase the platelet yield from donors, but aren’t likely to be the treatment of choice for thrombocytopenia.

Plasma

Plasma, the major noncellular blood component, is a fluid containing clotting factors, electrolytes, and proteins (including albumin). The red and white cells and platelets are suspended in plasma. Plasma is routinely removed immediately after blood donation, frozen, and stored for up to 1 year.

Fresh frozen plasma is indicated for:
- preoperative or bleeding patients who need replacement of multiple plasma coagulation factors (for example, patients with liver disease)
- patients receiving massive transfusions who have clinically significant coagulation deficiencies
- patients taking warfarin who are bleeding or need to undergo an invasive procedure before vitamin K can reverse anticoagulation, or who need to have anticoagulation therapy after the procedure
- patients who have thrombotic thrombocytopenic purpura and need a transfusion or plasma exchange
- patients with selected coagulation factor deficiencies, congenital or acquired, for which no specific coagulation concentrates are available
- patients with rare specific plasma protein deficiencies, such as C-1-esterase.

Fresh frozen plasma carries the risk of viral transmission, despite a relatively new solvent-detergent technology for inactivating enveloped viruses. Because of the cost of this technology, the plasma from several hundred donors is pooled, treated, and aliquoted into individual units. This
process doesn’t deactivate nonenveloped viruses such as hepatitis A; one contaminated donor may contaminate the entire pool. Therefore, many clinicians still prefer using single-donor plasma.

Fractionating plasma separates proteins, such as albumin and the immunoglobulins. The resulting products are treated so that they’re no longer biologically active and are classified as pharmaceuticals. Albumin is most commonly used on critical patients and has multiple purposes to support hemostasis. Other protein products, such as immunoglobulin G, are administered for replacement therapy of a specific protein.

**Cryoprecipitate**

Cryoprecipitate was the first product available for treating classic hemophilia A. The precipitate is recovered from fresh frozen plasma that’s been thawed at controlled temperatures. The final product contains coagulation factor VIII, factor XIII, fibrinogen, von Willebrand’s factor, and fibronectin suspended in 15 to 20 mL of plasma.

The components in cryoprecipitate are now available individually as viral-inactivated pharmaceutical products, so clinicians can use only the required component. Cryoprecipitate use today is generally limited to those occasions when factor VIII and fibrinogen need to be replaced simultaneously. Because such conditions are rare, you may never have an occasion to administer this product.

The pharmaceutical components that have replaced cryoprecipitate are factor VIII and IX products. Originally, these products couldn’t be viral-deactivated and the potential of viral transmission, particularly hepatitis B and HIV, was alarmingly high. Recombinant DNA technology has eliminated viral transmission and has increased the safety of these components.

**Granulocyte concentrations**

Granulocyte therapy today is most often provided by administration of granulocyte colony-stimulating factor (G-CSF), which stimulates the production of neutrophils in the bone marrow. These biologic response modifiers direct stem cells to develop into granulocytes. The medication is given as a subcutaneous injection for several days to weeks after chemotherapy or radiation to prevent neutropenia. It has a shelf life of only 24 hours.¹

The use of banked granulocyte concentrations was popular in the 1980s as treatment for neutropenia. However, the product had a short shelf life, caused serious adverse reactions, and was poorly tolerated by patients. Furthermore, the yield from 1 unit of pheresed white blood cells was less than the bone marrow would normally make in response to a serious infection. Today, granulocyte concentrations are given only in the presence of severe infection when neutropenia is also present. Donor bone marrow is stimulated before apheresis by the administration of G-CSF or dexamethasone so that yields are much greater than before. The product is irradiated before transfusion to reduce the risk of GVHD. Granulocyte products are stored at room temperature and have a shelf life of only 24 hours.¹

**What the future holds**

Thanks to today’s stringent donor screening and sophisticated testing, transmission of infectious diseases, such as HIV, through blood components is no longer a major issue. However, new viruses and parasites are constantly surfacing to threaten the blood supply. Processes used to destroy enveloped viruses (such as hepatitis B and C) have been very effective and likely will continue to provide the greatest safeguard to the blood supply. However, donor exclusion is still an important part of blood transfusion safety and donors are routinely turned away because of potential exposure to hepatitis or CJD.

Human error still accounts for the most serious problems that occur with blood transfusion. Requirements for bar coding of drugs and biologics can help reduce the chances of recipient-product mismatches. By understanding major blood products and their roles in therapy, you can help your patient get safe, appropriate treatment.

**REFERENCES**


**RESOURCES**


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