Blood Components for Pediatric Transfusions

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Blood transfusion plays an important role in the treatment of sick children, just as do pharmaceutical medications, intravenous fluids, and nutritional supplements. Unlike these therapeutic tools, however, blood is not manufactured in a factory but obtained from volunteer donors. Today, donated blood is rarely transfused as whole blood, and individual components are most often transfused to address the specific needs of the recipient. Blood can be obtained first as a whole blood donation with subsequent separation into components via centrifugation, or specific blood components can be directly obtained via apheresis. Blood components undergo leukocyte depletion before storage and further processing, thus arriving at hospital blood banks already leukoreduced, obviating the need to use bedside leukocyte filters.

Packed red blood cells (pRBCs), the most commonly transfused blood component, can be obtained directly via apheresis or by centrifugation of whole blood. After leukoreduction, pRBCs can be stored in citrate, phosphate, dextrose, adenine (CPDA) solution to achieve a shelf life of 35 days, or with additive solutions, such as adenine, dextrose, sorbitol, sodium chloride, and mannitol (ADSOL), to achieve a longer shelf life of 42 days. Whereas the hematocrit level of a CPDA unit is 65% to 80%, that of a unit prepared with additive solution is 55% to 65%. This difference in hematocrit value affects the volume calculations for transfusion, as shown in the Table, and should be considered in situations when there is a need to avoid overly high hematocrit levels, as in patients with sickle cell disease receiving partial exchange transfusions.

pRBC units are stored at refrigerator shelf temperature of 1°C to 6°C. When a pRBC unit leaves the blood bank, regulations dictate that it must be used for transfusion within 4 hours and otherwise discarded. Transfusions of pRBC units are usually given over 2 hours to stable patients. Transfusions should be given more slowly to patients who have very low hematocrit levels from chronic anemia to avoid precipitating heart failure. Because the transfusion time cannot be extended over the 4-hour limit, smaller aliquots of 5 to 6 mL/kg of body weight should be given in such cases.

Platelet units come in 2 forms: random donor platelets, which are obtained via centrifugation of a whole blood donation, and single donor units, which are obtained via apheresis. Whereas random donor platelets units have a volume of ~50 mL and contain at least 5.5×10^{10} platelets per unit, apheresis units have a volume of ~250 mL and contain at least 30.0×10^{10} platelets per unit. Blood processing centers in the United States have largely shifted to collecting apheresis platelets; platelets obtained from whole blood donations are usually discarded. If obtained, 4 to 6 random donor units are usually pooled into 1 unit. Most experts do not recommend transfusing more than 6 random donor units or 1 single apheresis unit at a time.

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TABLE. **Doses of Blood Components for Pediatric Use**

BLOOD COMPONENT	DOSE
Packed red blood cells prepared in citrate, phosphate, dextrose, adenine	5 mL/kg to elevate hemoglobin by 1–1.5 g/dL (10–15 g/L) 10 mL/kg to elevate hemoglobin by 2–3 g/dL (20–30 g/L)
Packed red blood cells prepared in additive solution	6 mL/kg to elevate hemoglobin by 1–1.5 g/dL (10–15 g/L) 12 mL/kg to elevate hemoglobin by 2–3 g/dL (20–30 g/L)
Random donor platelets	1 U for every 10 kg
Apheresis platelets	5–10 mL/kg
Fresh frozen plasma	10–15 mL/kg
Cryoprecipitate	1–2 U for every 10 kg
Granulocytes	10–15 mL/kg

Platelets are stored at room temperature, which may facilitate bacterial growth in the platelet unit. In fact, platelet units are the components most often associated with bacterial sepsis in the recipient. To avoid this complication, processing centers have elected to culture platelet units before issuing them to blood banks. Units that signal bacterial growth are discarded, and only those with negative growth are issued to blood banks. This process diminishes the already short shelf life of platelets by up to 2 days, and most units that reach the blood bank have only 3 to 5 days until expiration.

Two different methods have been developed to avoid infection from platelet transfusion. In the first, platelets undergo a process called *pathogen inactivation:* although labor-intensive, the process, which involves treating the platelets with amotosalen, eliminates the need to culture them. Amotosalen-injected units are exposed to UV-A rays, breaking down the psoralen-bound DNA of viruses, bacteria, and white blood cells. Platelets, being anuclear, are not affected by this process. Alternatively, platelet units at day 6 or 7 can be screened for bacterial growth before being issued for transfusion.

Many blood banks issue platelet units without regard to ABO compatibility between the donor and recipient. However, platelets do carry ABO antigens, and a transfusion to a recipient with a major incompatibility may lead to "platelet refractoriness," meaning an unexpectedly low rise in the platelet count after transfusion. Although platelet refractoriness can have other causes, most experts recommend attempting transfusion with ABO-compatible platelets before embarking on a search for another cause, such anti–human leukocyte antigen (HLA) antibodies. Because platelets are also contaminated with minute amounts of RBCs, Rh sensitization is a risk if a unit obtained from an Rh-positive donor is transfused to an Rh-negative recipient. Rh-negative women of reproductive age should receive Rh-negative units or anti-D injections to avoid sensitization after a transfusion of Rh-positive platelets.

The 2 most commonly transfused plasma-based blood components are fresh frozen plasma (FFP) and cryoprecipitate. Although both clinicians and blood bankers continue to refer to the plasma units as FFP, the technically correct term for most units is *PF24* (plasma frozen within 24 hours after phlebotomy), which is similar to actual FFP except that it contains lower concentrations of factor VIII and factor V. Many hospitals use the product *thawed plasma* interchangeably with FFP and PF24. For the rest of this discussion, we will continue to use the commonly used (albeit incorrect) designation *FFP*. Both FFP and cryoprecipitate are stored at freezing temperatures of less than or equal to −18°C and can be stored for up to a year. Thawed units should be transfused at a rate of 10 to 20 mL/kg per hour because clotting factors start degrading with every passing hour at room temperature.

FFP is, unfortunately, the blood component most commonly transfused for inappropriate indications in hospitals. Such inappropriate use may involve the treatment of prolongation of prothrombin time or activated partial thromboplastin time in the absence of clinical bleeding, supplementation of volume or albumin, or replacement of

coagulation factors for which individual factor concentrates are readily available.

Cryoprecipitate, manufactured from the precipitated portion of plasma thawed at 1°C to 6°C, contains 4 important coagulation factors: factor VIII, von Willebrand factor, factor XIII, and fibrinogen. Specific concentrates for each of these individual factors now are available, thus decreasing the use of cryoprecipitate as a treatment for specific clotting factor deficiencies. However, it is still commonly used to replenish fibrinogen in states such as disseminated intravascular coagulation because fibrinogen concentrate is not easily available and is more expensive.

Transfusions of granulocytes had fallen out of favor because of severe adverse effects, including acute respiratory distress syndrome, but are now making a comeback for severely neutropenic patients with severe sepsis. Complications and availability are still significant issues with the use of this blood component. In addition, before donation, common practice is for the donor to receive granulocyte colony-stimulating factor injections or corticosteroids to increase blood granulocyte numbers.

To prevent transfusion-associated graft-versus-host disease, cellular blood components such as pRBCs and platelets should be irradiated before transfusion to patients with immunodeficiency states, including infants younger than 4 months, children receiving chemotherapy, or after a hematopoietic stem cell transplant. Irradiation is also indicated for blood units donated by family members. Irradiation does have undesirable consequences: it reduces the shelf life of pRBCs and increases the potassium level in each unit, which may become a significant problem in patients with renal compromise.

COMMENT: Our authors note that FFP is too often transfused inappropriately. Recent evidence now suggests that we may also be transfusing pRBCs more frequently than necessary. Several studies have looked at what is the optimal hemoglobin threshold for transfusing anemic patients. The consensus in studies that looked at children in ICUs with sepsis and with blood loss after surgery is that a more restrictive threshold is as safe as one that is more liberal: ~7 g/L instead of 9 to 10 g/L. Aside from its expense, the transfusion of pRBCs does not come without the risk of adverse effects, and using the lower threshold reduced the number of transfusions by almost half.

Also mentioned by the authors is that blood products donated by family members should be irradiated before use. At least to me, the reason for this is not as obvious as the need for irradiation to protect recipients who are immunocompromised. It turns out, especially as evidenced by studies conducted at the height of the AIDS epidemic, that family members, whether from embarrassment or feeling threatened, are likelier than random donors not to disclose their exposure to or infection with contagious pathogens. And thus the need for extra precaution. Furthermore, studies reveal that with units donated by family members the risk of lymphocyte engraftment is increased if the donor and patient have similar HLA types and particularly if the donor is homozygous for an HLA haplotype to a heterozygous recipient. This translates into a higher risk of transfusion-associated graft-versus-host disease.

– Henry M. Adam, MD
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