Storage, however, impairs red cell function. Stored blood initially delivers oxygen to the tissues less efficiently. Although PRBCs are maintained at 1 to 6°C, cell metabolism continues, and changes occur. These changes are collectively referred to as the “storage lesion.” Documented alterations are numerous and include a decrease in both pH and the level of 2,3-diphosphoglycerate (2,3-DPG). In addition, the deformability of stored RBCs changes over time, making them more spherical and rigid, increasing resistance to capillary flow. After infusion, however, many of these changes are readily reversed. The decrease in 2,3-DPG, for example, results in a left shift in the Hgb-oxygen dissociation curve, but 2,3-DPG levels begin to recover within minutes and are fully restored within 24 hours. Further complicating the issue, the relationship between overall oxygen transport and oxygen delivery to tissues is complex. Depletion of S-nitrosohemoglobin during storage, for example, alters oxygen-dependent regulation of microcirculatory blood flow (“hypoxic vasodilation”). Research and debate are ongoing with regard to whether and when these and other changes are clinically significant, and how they might be addressed.

Additional well-established changes in stored blood include cell leakage of potassium, although the amount (approximately 6 mEq/U) is readily tolerated by most otherwise healthy patients. PRBCs contain essentially no functional platelets or granulocytes.

**Blood Typing**

The appropriate ordering of blood bank products and services is facilitated by a basic understanding of compatibility testing, which identifies clinically significant blood antigens and antibodies. When a clinician anticipates that transfusion might be indicated, a type and screen is often ordered. A blood specimen from the patient is then sent for the following tests: ABO grouping, Rh typing, and an antibody screen for unexpected antibodies (non-ABO/Rh antibodies). Completion of these steps speeds the delivery of crossmatched blood if it is subsequently required.

Identified RBC antigens include the ABO and related carbohydrate antigens (H, P, I, and Lewis), the 48 Rh system antigens, and more than 200 non-ABO/Rh antigens. ABO incompatibility results in acute hemolysis, the most serious transfusion reaction.

ABO grouping requires that the recipient’s red cells be tested with anti-A and anti-B serum and that his or her serum be tested with A and B red cells. At about 6 months of age, patients form antibodies against the A and B antigens they lack. Those with type AB blood form no ABO group antibodies. Patients with type O have antibodies against both. The major clinically significant Rh antigen is the D antigen. Rh typing is usually done by adding a commercial reagent (anti-D) to recipient RBCs.

The antibody screen identifies unexpected antibodies in the patient’s serum. These result from prior exposure to foreign RBC antigens during allogenic transfusion or pregnancy. The antibody screen entails mixing commercial RBC reagents (mixtures of red
cells expressing clinically significant antigens) with the patient's serum. The incidence of these unexpected antibodies in the general population is low (<1-2%), but a positive screen prompts further compatibility testing, which can take hours to days. When transfusion is delayed by a positive antibody screen in a critically ill patient, clinicians should communicate directly with the blood bank to determine the best course of action. Although ABO compatibility is mandatory in all patients, non-ABO antigens are very unlikely to cause immediate intravascular hemolysis. Administering blood that is not completely crossmatched is therefore an option if the need is emergent.

The type and screen allows for quicker selection of appropriate banked blood for complete crossmatch if a transfusion is later ordered.

When a unit of blood is ordered for transfusion, a crossmatch is done. In an ideal situation, blood identical to the patient's own ABO and Rh group is used. Local blood supplies, however, might dictate that a nonidentical but compatible unit be used. Patients with blood group AB (who lack anti-A and anti-B antigens), for example, are "universal recipients"—they can receive blood from any of the ABO groups. Type O blood (lacking the A and B antigens), also known as "universal donor" blood, conversely, can be given to anyone. Rh compatibility is also important. Rh sensitization can occur in Rh-negative patients exposed to Rh-positive blood, and this sensitization in turn can result in hemolytic disease of the newborn with subsequent pregnancies.

The traditional crossmatch requires mixing recipient serum with donor RBCs and observing for agglutination as a final compatibility test before transfusion. If the antibody screen is negative, an "immediate spin crossmatch" at room temperature serves as a final check for ABO incompatibility. A "complete crossmatch" is generally done before transfusion if the antibody screen is positive. This requires incubation to 37°C and the addition of antihuman globulin (Coombs' reagent) to promote agglutination. Many blood banks also substitute a "computer crossmatch" for patients whose blood has been tested at least twice within their system. Decisions about which method is used, however, are generally made by the blood bank, not the clinician.

**Special Clinical Circumstances**

To select the most appropriate blood products in the emergency setting, clinicians should consider the patient's hemodynamic stability, the likelihood of ongoing hemorrhage, and the amount of time available to intervene. When time is short, waiting for fully crossmatched blood may result in a dangerous delay, and alternatives should be considered. When the clinician anticipates large and ongoing blood losses, complications resulting from massive transfusion are a concern as well.

**Administering Blood before Completion of Compatibility Testing**

Full compatibility testing takes time. An antibody screen and immediate spin crossmatch at a minimum take approximately 45 to 60 minutes. This assumes a negative antibody screen followed by an immediate spin crossmatch performed at room temperature. If the antibody screen is positive, the antibody is identified via more elaborate procedures, and a complete crossmatch (using a Coombs test with incubated serum) is required. This process can take up to several hours (or even days), an unacceptable delay in some emergent situations.

Universal (group O) blood is used when RBCs are needed in hemorrhaging, unstable patients before any testing can be done. Female patients receive O-negative blood to prevent hemolytic disease of the newborn unless there is no chance of subsequent pregnancy. All others receive O-positive blood, because even if sensitization occurs, Rh antibodies generally do not fix complement and therefore would be unlikely to cause an acute intravascular hemolytic reaction in the unlikely event that an Rh-negative recipient twice received emergent transfusion of Rh-positive blood. Conversely, the "universal" type for fresh frozen plasma (FFP) is type AB, which contains no antibodies to either A or B antigens.

Type-specific blood (with ABO and Rh testing) can generally be made available within 15 minutes of receiving a sample of the patient's blood.

**Massive Transfusion**

Massive transfusion has no formal definition. Administration of at least 10 units of RBCs in 24 hours is a commonly used cutoff. Although patients receiving any amount of blood are susceptible to a variety of infectious, physiologic, and immunologic insults, this section will discuss those uniquely associated with massive transfusion.

Some of these complications are well understood and easily managed. Hypothermia is common in these patients, and can reduce clotting factor activity. Warmed intravenous fluids, blood warmers, and warming lights and blankets are often needed. Frequent laboratory testing will identify electrolyte disturbances (low magnesium and calcium, and both high and low potassium), which are in general treated in a standard fashion by replenishing deficits, or administering calcium for hyperkalemia. Acidosis is a common finding with massive hemorrhage but can also be caused by hypoperfusion, and the contribution of transfused blood to acidosis is felt to be variable. Citrate from banked blood, for example, is metabolized in the liver to bicarbonate, which can sometimes result in metabolic alkalosis. With rapid infusion or reduced hepatic function, however, this pathway can be overwhelmed, and the net effect of infusing large amounts of citrate can be worsening metabolic acidosis. A rational response to metabolic acidosis is to optimize oxygen delivery and ventilation. Administering sodium bicarbonate may be considered in severe cases, but the benefits are less certain.

Patients receiving massive transfusion are also prone to coagulopathy and thrombocytopenia. Consumption and dilution of clotting factors and platelets occur in these patients owing to ongoing hemorrhage, fluid boluses, and transfusion of PRBCs. This undoubtedly plays a role in the coagulopathy of trauma, but recent research asserts that coagulopathy often occurs in massive trauma even before these mechanisms have taken effect. A number of reports (none of them from randomized prospective trials) have stated that a more proactive approach to administering plasma and platelets in massive transfusion is associated with better outcomes.

In response, many institutions have adopted massive transfusion protocols that call for plasma (and often platelets) to be given in a 1:1 ratio with RBCs. When set ratios are not used, clinical assessment and judgment often augment laboratory values such as international normalized ratio (INR), partial thromboplastin time (PTT), and fibrinogen and platelet counts because there is no direct evidence supporting any particular threshold for platelet or coagulation factor replacement in patients with severe hemorrhage. Commonly recommended goals in this setting would be to consider maintaining an INR below 1.5, a fibrinogen level greater than 1 to 2 g/L, and platelet count above 50,000 to 100,000/µL.

**Administration**

**Legal Aspects**

Before a blood product can be infused, two qualified personnel check it at the bedside to prevent a potentially fatal clerical error.
This check includes recipient and unit identification, as well as confirmation of compatibility, and the expiration date.

If typed and crossmatched blood arrives with the patient from a transferring facility, it is important that the temperature be maintained between 1 and 10° C during transport. If the blood is not used right away and the blood bank is asked to hold the blood for the patient, it is processed and crossmatched as for other issued blood and quarantined for 24 hours. It can be sent back to the blood bank to have this done only if (1) it has been constantly maintained at a temperature between 1 and 10° C, (2) all container seals are intact, and (3) tubing segments have remained attached to the blood container.

Infusion Adjuncts

Urgent transfusion situations require flow rates faster than gravity can provide. An administration set with an in-line pump that is squeezed by hand is the simplest method to speed infusion. Pressure bags are also available that completely encase the blood bag and apply pressure evenly. With high-pressure infusion, large-bore needles are recommended so that hemolysis is prevented.

If only a small-gauge needle is available, the transfusion may be diluted with normal saline, but this may cause unwanted volume expansion. In elective transfusions, no significant hemolysis occurs when small-gauge needles are used if the maximum rate of infusion is less than 100 mL/hr.

**Managemen**

**Decision-Making**

In considering the use of blood component therapy, the patient’s age, severity of symptoms, cause of the deficit, underlying medical condition, ability to compensate for decreased oxygen-carrying capacity, and tissue oxygen requirements are all important. Clinical evaluation, including appearance (pallor, diaphoresis), mental status, age, severity of symptoms, cause of the deficit, underlying medical condition, and tissue oxygen requirements are all important. Clinical evaluation, including appearance (pallor, diaphoresis), mentation (alert, confused), heart rate, blood pressure, and the nature of the bleeding (active, controlled, uncontrolled), can be supplemented by laboratory evaluation.

A review of relevant literature supports the recent trend toward more conservative red cell transfusion triggers but also highlights the need for further investigation. The same can be said for FFP and other blood components. Benefits of transfusion have been difficult to prove, and the list of known and suspected associated risks is long and growing.

Whole Blood

Intriguing reports on the use of fresh whole blood in military field hospitals have been published, but in civilian practice in the United States, it is generally unavailable and rarely used.

Packed Red Blood Cells

PRBCs are indicated only to improve oxygen delivery to tissues at the microvascular level and thus improve intracellular oxygen consumption. It bears repeating that demonstration of the efficacy of red cells for this purpose (or improved clinical outcomes) has proven elusive. A definitive randomized prospective study in which RBCs are withheld completely from one treatment group is unlikely to be done at this point. For decades, transfusion of RBCs was guided by the so-called “10/30 rule”: transfusion was indicated for an Hgb of less than 10 g/dL or a hematocrit of less than 30%. This practice is outdated. The largest published randomized trial in adult patients to date, the TRICC (Transfusion Requirements in Critical Care) trial, demonstrated that in the critical care setting, a transfusion threshold of 7 g/dL was as safe as a threshold of 10 g/dL. In this trial there was some concern that a higher trigger was more appropriate in patients with coronary artery disease (CAD). The FOCUS trial (Functional Outcomes in Cardiovascular Patients Undergoing Surgical Hip Fracture Repair) addresses this specific population, and results support a restrictive 8 g/dL trigger for red cell transfusion in these patients as well.

Absent further research, the recommendations of the American Society of Anesthesiologists seem reasonable: transfusion is rarely needed with an Hgb concentration greater than 10 g/dL and is usually needed when the Hgb is less than 6 g/dL. Patients with an Hgb of 6 to 10 mg/dL require careful clinical judgment. Guidelines published in 2009 by the Eastern Association for the Surgery of Trauma and the American College of Critical Care Medicine and based on a thorough review of the available evidence likewise support this conservative strategy, advocating a cutoff of Hgb below 7 g/dL for most stable patients. Lastly, most emergency physicians would still transfuse any patient with ongoing severe hemorrhage and unstable vital signs despite adequate fluid resuscitation and would occasionally consider withholding transfusion for Hgb levels even lower than 6 g/dL in a young, healthy, asymptomatic patient at low risk for further bleeding. Another interesting area of investigation is the use physiologic transfusion triggers (such as lactate or mixed venous oxygen saturation), but further research is needed.

Artificial Oxygen Carriers

Research into both Hgb-based oxygen carriers and perfluorocarbon emulsions is ongoing, but as yet none are approved for general clinical use in the United States. Several problems remain unsolved. Hgb-based carriers, for example, have been found to cause vasoconstriction through nitric oxide (NO) scavenging, endothelin release, and peripheral alpha-adrenergic receptor sensitization. Perfluorocarbon emulsions require relatively high partial pressure of oxygen (PO2) levels. When these emulsions are used clinically, pure oxygen is usually administered as well. It appears unlikely that artificial oxygen carriers will come into widespread emergency department (ED) use anytime soon.

Fresh Frozen Plasma

As noted previously, evidence from retrospective trials supports increased use of FFP in patients undergoing massive transfusion. This should not be generalized to all patients receiving transfusion, however. A retrospective case-control trial of 1716 transfused trauma patients receiving fewer than 10 units of blood found that administration of FFP was associated with no survival benefit, yet with a higher risk of complications, including acute respiratory distress syndrome (ARDS), pneumonia, sepsis, and multiple organ dysfunction. As with RBCs, indications for FFP are based primarily on observational trials and expert opinion. The following indications seem reasonable based on current evidence: coagulopathy of trauma, hemorrhaging patients with coagulopathy resulting from hepatic dysfunction or disseminated intravascular coagulation (DIC), plasma exchange for thrombotic thrombocytopenic purpura (TTP), and emergency reversal of a vitamin K antagonist in the presence of clinically significant hemorrhage. Because of the volume of FFP needed to reverse coagulopathy caused by vitamin K antagonism (at least 10 mL/kg, and perhaps as much as 30 mL/kg), however, some guidelines call for the use of prothrombin complex concentrate or recombinant factor VIIa instead, although neither is currently approved by the U.S. Food and Drug Administration (FDA) for this indication in the United States. FFP is not indicated for volume expansion, nonurgent reversal of a vitamin K antagonist, or treatment for abnormal INR from any cause in the absence of bleeding.
Likewise, limited available evidence fails to support the use of FFP in patients with an elevated INR before invasive procedures such as central line placement and lumbar puncture, although it is common practice to administer FFP for an INR greater than 1.5 to 2.0. One problem has been that the INR often proves poorly predictive of clinical bleeding. Thromboelastography, an old technology attracting renewed interest, may prove useful in guiding coagulation therapy but is not now widely used in the ED setting. A full description is beyond the scope of this chapter, but this test provides information on function of both platelets and coagulation factors (including fibrinogen).

If a specific factor deficiency is identified (e.g., hemophilia), targeted replacement of that factor, if available, is usually more practical.

**Platelets**

Platelet transfusion is indicated prophylactically when the count is less than 10,000/µL, and this includes a margin of safety, as it appears that hemostasis is well maintained even at counts of 5000/µL (a threshold sometimes used for stable, afebrile inpatients). Platelets are often given to adults in a dose of 6 units of platelet concentrate (a “six-pack” of platelets), which typically raises the platelet count about 40,000 to 60,000/µL. Once again, however, this practice is not evidence based. Because hemostasis is maintained with platelet counts as low as 5000/µL, it seems likely that smaller, more frequent platelet transfusions should be equally efficacious, but more cost-effective, particularly in hospitalized patients. This practice is supported by a randomized trial that enrolled nearly 1300 patients undergoing prophylactic platelet transfusion, which demonstrated no increase in bleeding complications with use of a low, medium, or high dose of platelets (amounts corresponding to roughly 2, 4, or 6 units of platelet concentrate). This may be impractical in outpatients, in whom increasing the frequency of transfusion can be more of a burden, and discussion with the patient’s hematologist is often helpful. There are no large randomized trials on which to base recommendations for the use of prophylactic platelet transfusion before invasive bedside procedures such as lumbar puncture or central line placement. Retrospective data support the safety of performing lumbar puncture with platelet counts as low as 10,000/µL. For central line placement, a platelet count of 20,000 to 30,000/µL is generally considered adequate, and for major surgery, a count of 50,000/µL is generally acceptable, although higher cutoffs (70,000-100,000/µL) are often used for neurosurgical and retinal procedures. Another interesting consideration is whether a patient is anemic. Red cells tend to push platelets to the periphery of the vessel, where they are needed to patch endothelial disruptions. Patients with anemia appear more prone to bleeding. Lastly, when thrombocytopenia results from immune-mediated platelet destruction caused by idiopathic thrombocytopenic purpura (ITP) or TTP, transfusion is generally ineffective. If, however, immune-mediated destruction is a result of human leukocyte antigen (HLA) sensitization from prior transfusions, then HLA-matched single-donor platelets collected with apheresis methods may be helpful. Consultation with a hematologist is advisable in such cases.

**Autotransfusion**

Autotransfusion may be used in the emergency setting in the event of severe chest trauma. This strategy has numerous advantages: immediate availability, blood compatibility, elimination of donor-to-patient disease transmission, avoidance of the storage lesion, lower risk of circulatory overload, and fewer direct complications (e.g., hyperkalemia, hypothermia, hypocalcemia, and metabolic acidosis). It is also more acceptable to patients whose religious convictions prohibit transfusions. It is impractical in some settings, however, because of the limited number of appropriate trauma patients, the training required to operate the equipment, and the time required for equipment setup.

**Therapeutic Modalities**

**Packed Red Blood Cells**

In acute hemorrhage, PRBCs are used to supplement initial crystalloid replacement. In an average adult, 1 unit (450 mL) of PRBCs increases the Hgb by about 1 g/dL or the hematocrit by about 3%. A similar increase in pediatric patients is obtained by administering 10 mL/kg. PRBCs are run through a filter with a large-bore intravenous line with normal saline. Lactated Ringer’s solution can lead to clotting secondary to the added calcium, and hemolysis may result with a hypotonic solution. Medications should not be added to the unit or pushed through the transfusion line unless it has been thoroughly flushed. Most transfusions are given over 60 to 90 minutes (never longer than 4 hours). Unused blood should be returned promptly to the blood bank. Any units unrefrigerated for more than 30 minutes are discarded.

**Fresh Frozen Plasma**

A unit of FFP contains all clotting factors and typically has a volume of 200 to 250 mL. It must be ABO compatible and is given through blood tubing. FFP can be used to replace the most labile components (factors V and VIII), but it is given within 24 hours of thawing. An alternative product, referred to as “thawed plasma,” contains the vitamin K–dependent factors, which are stable for up to 5 days after thawing. One unit of activity for any coagulation factor is equal to the clotting activity found in 1 mL of FFP. As noted previously, appropriate dosage is not well grounded in evidence from clinical trials. In massive transfusion, many centers now use FFP in a 1:1 ratio with red cells. For other indications it seems reasonable to start with infusions of 10 to 30 mL/kg, realizing that results will be somewhat unpredictable and follow-up laboratory and clinical assessment will be necessary.

**Platelets**

Crossmatching is generally unnecessary, but Rh-negative patients are treated with Rh-negative platelets because there may be enough red cells in the platelet concentrate to cause Rh sensitization. In adults the traditional dose has been 4 to 6 units (a “six-pack” of platelets), and in children it is 1 U/10 kg body weight. As noted earlier, however, use of smaller, more frequent transfusions is considered in patients who are being admitted. In frequently transfused patients, it is often desirable to reduce HLA sensitization with leukoreduced platelets. Once sensitization has occurred and patients have developed immunemediated platelet refractoriness, a trial of single donor (apheresis) HLA-matched or crossmatched platelets may be considered in consultation with a hematologist.

**OUTCOMES**

Adverse effects of RBC transfusion can be divided into immunemediated and non–immunemediated categories, as well as acute, delayed, and chronic effects.

**Immune-Mediated Adverse Effects**

**Acute**

Intravascular Hemolytic Transfusion Reaction. Intravascular hemolytic transfusion reaction is the most serious transfusion reaction.
It is usually the result of ABO incompatibility, most often caused by clerical error. The resulting antigen-antibody reaction leads to the intravascular destruction of transfused red cells, producing hemoglobinemia and hemoglobinuria. The onset of symptoms is immediate and may include any of the following symptoms: fever, chills, headache, nausea, vomiting, a sensation of chest restriction, severe joint or low back pain, and a burning sensation at the site of the infusion. A feeling of impending doom is often mentioned.21 Clinical effects can include hypotension, DIC, and acute tubular necrosis. Treatment includes stopping the transfusion immediately, replacing all old tubing with new, and initiating vigorous crystalloid fluid therapy. Diuretic therapy can also be used to maintain urine output at 1 to 2 mL/kg/hr. Some patients may require pressors. Blood and urine specimens are sent to the laboratory, as well as the remainder of the transfusion and the blood tubing. Detection of free Hgb (blood and urine) and a positive result of Coombs’ test on post-transfusion, but not pretransfusion, specimens confirms the diagnosis.21

Febrile Transfusion Reaction. Febrile transfusion reaction is the most common and least serious transfusion reaction. It is defined as a 1°C or greater temperature elevation that occurs with transfusion and for which no other medical explanation is found. Reactions are believed to result from antileukocyte antibodies, most commonly as a result of prior transfusion. Treatment is symptomatic with analgesics, antipyretics, and antihistamines. The use of leukoreduced RBCs can help decrease, but not eliminate, the risk of this reaction.15,21 If a febrile reaction occurs in a first-time transfusion, it should be treated in the same way as an extravascular hemolytic reaction until proven otherwise.

Allergic Reactions (Urticaria to Anaphylaxis). Urticaria, or hives, may occur during a transfusion without other signs or symptoms and with no serious sequelae. It is generally attributed to an allergic, antibody-mediated response to a donor’s plasma proteins. The transfusion does not need to be stopped, and treatment with an antihistamine is usually sufficient. Consider prophylactic antihistamines in patients with a history of this reaction. Occasionally, full anaphylaxis may be caused by an anti-immunoglobulin A (IgA) reaction to IgA in the donor’s blood components. The patient is likely to have a genetic IgA deficiency. Presentation is similar to anaphylactic reactions from other causes. Treatment is with epinephrine and corticosteroids. Use of washed RBCs, and plasma products from IgA-deficient individuals can be used to avoid recurrence with subsequent transfusions.15

Transfusion-Related Acute Lung Injury. Transfusion-related acute lung injury (TRALI) is now considered the leading cause of transfusion-related mortality.12 It has been defined as new acute lung injury (ALI) resulting in bilateral pulmonary edema and hypoxemia (ratio of arterial oxygen concentration to fraction of inspired oxygen [Pao2/Fio2] ≤300, or oxygen saturation as measured by pulse oximetry <90% on room air) and occurring during or within 6 hours after a transfusion without temporal relationship to an alternative explanation for ALI. If an alternative explanation is also present, the diagnosis of possible TRALI is appropriate.75 Implicated blood components include PRBCs, FFP, platelets, and cryoprecipitate. The initial clinical presentation is that of a noncardiogenic pulmonary edema, with dyspnea, hypoxemia, and bilateral infiltrates on chest radiograph. Fever, hypotension, and transient leukopenia may also be seen. The underlying pathophysiologic mechanism is a subject of continuing debate and could involve multiple insults.76 Proposed theories include a reaction between transfused antibodies and leukocytes in the recipient, as well as the effects of biologically active factors that accumulate in stored blood, such as cytokines and lipids.77 One strategy suggested for reducing TRALI has been to use only male donors for plasma in order to avoid allotypic leukocyte antibodies, which can occur in women as a result of prior pregnancies, or to screen for these antibodies and exclude donors when the antibodies are found.78,80 Appropriate treatment consists of stopping the transfusion, notifying the blood bank, and providing respiratory support, which may include intubation and mechanical ventilation. It is safe to continue transfusion of blood products from a different donor, if necessary. Complete resolution is usually seen within 48 to 96 hours. Overall prognosis is better than would be expected with many other causes of ALI, with a reported mortality rate of 6% in one series.81 Survivors rarely show long-term adverse effects.81

Delayed

Extravascular Hemolytic Transfusion Reaction. Extravascular hemolytic transfusion reactions result from a non-ABO-mediated immune reaction, most often caused by an anamnestic response in a patient previously sensitized to red cell antigens by transfusion, pregnancy, or transplant. This prior exposure may result in antibody levels that are too low to detect with the antibody screen. After repeat exposure from transfusion, however, antibody levels rise, and extravascular hemolysis occurs days to weeks later. Less commonly, primary alloimmunization can occur after transfusion. The patient may have fever, anemia, and jaundice. Symptoms are not usually severe, but rare cases of oliguria or DIC do occur. Because the hemolysis is extravascular, hemoglobinemia and hemoglobinuria are generally absent.15

Transfusion-Associated Graft-versus-Host Disease. A rare but life-threatening complication, transfusion-associated graft-versus-host disease results when transfused lymphocytes proliferate and attack the recipient. Mortality is greater than 90%. Cell-mediated immunodeficiency puts patients at risk, as does having an HLA type that is identical between donor and recipient (most often among first-degree relatives). Symptoms, which begin 3 to 30 days after transfusion, include fever, erythematous skin rash, diarrhea, elevated liver enzymes, and pancytopenia. The only effective treatment is bone marrow transplant, and most deaths result from coagulopathy or infection. Efforts are therefore directed at prevention by using gamma irradiation of all cellular components, which renders the donor lymphocytes incapable of proliferating. The use of leukocyte-poor components is also advocated. This condition should be kept in mind when transfusion is being considered for anemic leukemia or lymphoma patients, especially those who have recently received chemotherapy.15

Non-Immune-Mediated Adverse Effects

Acute

Circulatory Overload. Chronically anemic, normovolemic elderly patients are at greatest risk for developing congestive heart failure with the rapid infusion of blood. Transfusing more slowly (over a period of 4 hours) and administering diuretics are useful in preventing this complication.15

Bacterial Contamination. Bacterial contamination, most commonly with Yersinia enterocolitica (which grows well in cool, iron-rich environments), occurs in fewer than 1 per million units of stored RBCs but typically results in symptoms during the transfusion and carries a 60% mortality rate.79 The risk of bacterial contamination is greater, however, with platelets, which are stored at a higher temperature; contamination occurs as frequently as 1 per 1000 to 2000 units.89 During or after the transfusion, the patient may develop rigors, vomiting, abdominal cramps, fever, shock, renal failure, and DIC. If contamination is suspected, the transfusion should be stopped, blood cultures obtained from both the bag and the patient, and broad-spectrum antibiotics and hemodynamic support initiated.
Chronic Risk of Transfusion-Transmitted Viruses. Improved techniques for selecting and testing blood donors have dramatically reduced the risk of viral transmission of disease by transfusion. It is believed that the blood supply in the United States has never been safer.49 Current estimates for the risk of acquiring hepatitis C and human immunodeficiency virus (HIV) infection from transfusion are 1 in 1,000,000 to 2,000,000.82 The risk of hepatitis B infection, however, remains closer to 1 in 200,000 to 500,000.83 Cytomegalovirus (CMV) can be transmitted by blood transfusion as well, but this risk can be decreased by leukoreduction. Those at risk include recipients of allogeneic stem cell or solid-organ transplantation and neonates. CMV-negative blood products should be considered in these patients.83,84 West Nile virus briefly emerged as a risk, although one that varied considerably by geography and season.49 Transfusion-related infection with West Nile virus, however, has been virtually eliminated by the use of system-wide nucleic acid amplification testing.83

The references for this chapter can be found online by accessing the accompanying Expert Consult website.
References

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