**Transfusion Medicine**

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New 2021 Questions

1. A 16-year-old female patient with severe factor XI deficiency presents with acute appendicitis and requires urgent surgery. You are called by the surgeon, who wants to know what, if any, blood products or treatments are required to reduce the risk of perioperative bleeding. The patient weighs 62 kg. What should you tell him to administer?

A. Cryoprecipitate (five units), which will likely raise her factor XI level to 20%

B. Factor XI concentrate (20 units/kg), which will raise her factor XI level to 20%

C. Fresh frozen plasma (20 mL/kg), which will raise her factor XI level to 20%

D. Prothrombin complex concentrate (40 units/kg), which will raise her factor XI level to 20%

E. Apheresis platelets at 10 mL/kg, which will raise factor XI level to 20% from the release of factor XI stored in platelet alpha granules

**Explanation**

The correct answer is C, fresh frozen plasma (20 mL/kg). Fresh frozen plasma is the only blood product that contains factor XI. Typically, 1 mL/kg of fresh frozen plasma will raise the factor level by 1%. Therefore, 20 mL/kg will increase factor XI level to 20%.

Cryoprecipitate contains fibrinogen and factors VIII and XIII, but not factor XI. Prothrombin complex concentrates contain factors II, IX, and X ± VII. Factor XI is neither produced by nor stored in platelets. There is no commercially available factor XI concentrate.

2. A 10-year-old patient with aplastic anemia, who is blood type B negative, is receiving a red blood cell transfusion. About 10 minutes after the transfusion starts, the patient develops anxiety and lower back pain. The transfusion continues for another 5 minutes until it is stopped when he develops a temperature of 40 °C with chills and rigors. A transfusion reaction work-up is most likely to reveal what findings?

A. Spherocytes on peripheral blood smear

B. Gram-negative *Bacillus* on gram stain of remaining RBC unit

C. Chest x-ray with bilateral pulmonary infiltrates that are new compared to an x-ray done last week

D. DAT positive for C3

E. Antibody screen positive for anti-Jka antibodies

**Explanation**

The correct answer is D, DAT positive for C3. The combination of fever, anxiety, and back pain within the first 10 to 15 minutes of a red blood cell transfusion is most consistent with an acute hemolytic transfusion reaction due to ABO incompatibility. Patients who have type B blood will have anti-A antibodies that will fix complement, leading to rapid intravascular hemolysis. Therefore, he will have a DAT positive for C3 (complement). Answer A describes IgG-mediated extravascular hemolysis that can either be due to autoimmune hemolytic anemia or delayed hemolytic transfusion reaction, which is typically 1 to 28 days after transfusion. Spherocytes are seen with a DHTR, not an ABO-incompatible AHTR. Answer B describes a septic transfusion reaction, which can present with fever but is more likely to also present with hypotension rather than anxiety or flank pain. Answer C describes the x-ray findings of a patient with transfusion-related acute lung injury (TRALI), which can present with fever but also respiratory symptoms. Answer E describes what may be found in a patient with delayed transfusion reaction due to evanescent anti-Jka antibodies that were not detected on the initial screening test.

3. A laboratory study is conducted to determine the optimal usage of platelets for transfusion. The blood bank inventory along with the transfusion records and medical records of subjects who were recipients of platelet transfusion are reviewed. Which of the following conclusions is most likely to be made from this study?

A. Frozen storage of platelets helps increase the units available.

B. Platelet transfusions are rarely successful in patients with autoimmune thrombocytopenia.

C. Platelet units carry no risk for transmission of hepatitis C infection.

D. Pooled donor platelets are preferred over single-donor platelets.

E. Platelet transfusion is not indicated above a level of 10,000/mcL.

The correct answer is B. Autoimmune thrombocytopenia is typically caused by antibodies against ubiquitous platelet antigens; therefore, transfused platelets are likely to be destroyed via the same mechanism as the patient’s own platelets. Platelets are stored at room temperature, not frozen. Platelet units can transmit all bloodborne pathogens, including hepatitis C. There is no significant advantage between whole blood–derived and apheresis platelets; each has advantages and disadvantages compared with the other. In most patients with hypoproliferative thrombocytopenia, a platelet transfusion threshold of 10,000/mcL is appropriate; however, many clinical situations may alter this threshold, including planned surgical or invasive procedures, medications such as anticoagulation, recent history, or current bleeding complications.

4. A 14-year-old male patient is diagnosed with very high risk acute lymphoblastic leukemia and is likely going to require an allogeneic hematopoietic stem cell transplant to cure his leukemia. Prior to going to transplant, he is likely to require multiple blood transfusions. Which of the following products or component modifications is the best way to prevent him from developing alloimmunization due to anti-HLA antibodies prior to transplant?

A. Frozen RBCs

B. Volume-reduced blood products

C. Irradiation of all blood products

D. Monthly IVIg infusions

E. Leukoreduced blood products

The correct answer is E, leukoreduced blood products. Avoidance of transfusions is the most effective way to reduce risk of alloimmunization; however, it may not be practical in patients receiving intensive chemotherapy regimens for hematologic malignancies. Leukoreduction of all blood products is effective in reducing contaminating WBCs, which have the highest density of HLA antigens on their surfaces. Frozen RBCs, while effective in reducing contaminating WBCs, are not a practical approach for transfusing patients unless they have hard-to-match RBC transfusion needs. Monthly IVIg infusions will neither prevent nor treat HLA alloimmunization. Irradiation is effective in preventing transfusion-associated graft-versus-host disease (TA-GVHD), but does not affect incidence of HLA alloimmunization.

5. A 2-year-old girl has a history of mild upper respiratory tract infections and mild diarrhea. She is a picky eater and drinks 32 oz of whole milk per day. Her father noticed she was pale and less playful during the past few days. Laboratory studies show Hgb 3.8 g/dL, Hct 11.3%, MCV 55 fL, platelet count 562,000/mcL, and WBC count 4,810/mcL. Her serum total protein is 7.5 g/dL, albumin 1.9 g/dL, IgG 1,123 mg/dL, IgM 208 mg/dL, and IgA not detected. Which of the following transfusion reactions is most likely to occur if she receives packed red blood cells (PRBCs)?

A. Anaphylactic transfusion reaction

B. Hemolytic transfusion reaction

C. Alloimmunization

D. Febrile nonhemolytic transfusion reaction

E. Allergic transfusion reaction

The correct answer is A, anaphylactic transfusion reaction. Although allergic and febrile transfusion reactions are more common than anaphylactic transfusion reaction, this question serves as a reminder that the Boards love the association of IgA deficiency and anaphylaxis. RBCs are less likely than platelets and plasma to be associated with allergic transfusion reaction or Febrile nonhemolytic transfusion reaction (FNHTR) because of the relatively lower volume of donor plasma. However, there is an estimate that about 1 in 100 blood transfusions in individuals with IgA deficiency will result in an anaphylactic transfusion reaction. The risk of reaction can be mitigated by washing or volume-reducing cellular products or transfusing products from a known IgA-deficient blood donor. Nothing in this patient’s history would suggest that she is at higher risk than average of developing alloimmunization or hemolytic transfusion reaction.

**Previous questions from 2019**

1. A 2-year-old girl, previously healthy, presents to a hospital with pallor and bruising. On physical exam, the patient has cervical lymphadenopathy and hepatosplenomegaly. CBC shows Hb 3.5 g/dL, WBC 1.2 × 103/mm3, platelet count 10,000/mm3, and reticulocytopenia. Direct antiglobulin test is negative for C3 and IgG. Before transferring the patient to your facility, the referring physician wants to transfuse her with packed RBCs and platelets.

What special product manipulation should you recommend?

A. Leukocyte reduction to eliminate the risk of bacterial contamination

B. HLA matching to eliminate the risk of HLA sensitization

C. Irradiation to eliminate the risk of transfusion-associated graft-versus-host disease (TA-GVHD)

D. Irradiation to reduce the risk of transfusion-transmitted cytomegalovirus (CMV)

E. Phenotype matching to reduce the risk of acute hemolytic transfusion reaction

**Explanation**

TA-GVHD occurs when donor T cells in transfused blood products recognize the recipient as foreign, mount an immune reaction, and proliferate. Recipients who are T-cell immunocompromised (from conditions such as T-cell malignancy, chemotherapy, or severe prematurity) are most vulnerable, and TA-GVHD has mortality rate of more than 90%. Irradiation inhibits T-cell proliferation and prevents TA-GVHD and is indicated for recipients who are potentially immunocompromised. Leukocyte reduction does not eliminate the risk of bacterial contamination. Irradiation does not reduce the risk of transfusion-transmitted CMV. HLA matching reduces the risk of HLA sensitization but is not indicated or practical in this instance. Phenotype matching does not reduce the risk of acute hemolytic transfusion reaction.

2. A 16-year-old girl presented to the emergency department with shortness of breath and dizziness. On physical exam, heart rate was 90/min, respiratory rate 20/min, blood pressure 110/60 mm Hg, and oxygen saturation 97% on room air. She was very pale, with scleral icterus and a 3/6 systolic ejection murmur at the left lower sternal border. There was no lymphadenopathy or hepatosplenomegaly. Hb was 3.2 g/dL, platelet count 450,000/µL, WBC count 5,600/µL, ANC 1,600/µL, and reticulocyte count 20%. Antibody screen was positive against all cells, and direct antiglobulin test was 3+ positive to IgG. Oxygen by nasal cannula was started, but the patient started displaying signs of confusion. The blood bank calls with the above results and reports that testing will take about 30 more minutes.

How will you manage this patient’s transfusion?

A. Wait to transfuse RBCs until underlying alloantibody has been ruled out.

B. Start steroids. Because the reticulocyte count is very high, this patient may not need RBC transfusion at all.

C. Transfuse uncrossmatched RBCs immediately because the patient is showing signs of poor cerebral perfusion.

D. Transfuse crossmatch-compatible RBC unit, even if underlying alloantibody has not been ruled out.

E. Perform RBC antigen phenotype on patient and give RBCs unit matched for patient’s minor RBC antigens to avoid RBC alloantibody formation.

**Explanation**

This patient likely has warm autoimmune hemolytic anemia (WAIHA), in which an IgG-type autoantibody against RBCs mediates RBC hemolysis, which is often brisk. Patients present with signs and symptoms of hemolysis, positive direct antiglobulin test to IgG, and an eluate that is positive against all reagent RBCs. To rule out underlying RBC alloantibody, adsorption of the patient’s serum is performed. Because the RBC autoantibody is usually directed against ubiquitous RBC antigens, there is no antibody specificity, and it is almost impossible to find crossmatch-compatible RBCs for transfusion. Therefore, patients with WAIHA usually receive crossmatch-incompatible units. Aside from transfusion for severe or symptomatic anemia, steroids are the first-line treatment for WAIHA.

RBC transfusion is indicated for treatment of anemia with moderate to severe symptoms of poor oxygen delivery. Emergent transfusion is indicated when signs of poor cerebral perfusion (confusion, loss of consciousness) or cardiorespiratory decompensation are present. In these instances the risk of transfusion of incompatible units is outweighed by the benefit of immediate oxygen-carrying capacity to vital organs.

In this case, with mental status deterioration, waiting for any workup before transfusing could have devastating consequences. Steroids should be started along with, but should not delay, RBC transfusion. Having reticulocytosis does not mean anything in the face of signs of decompensation from anemia.

3. A 2-year-old girl has *E. coli*–associated hemolytic uremic syndrome and anuria. Creatinine is 8 g/dL, serum K+ 6 mEq/L, Hb 6.5 g/dL, MCV 87 fL, platelet count 120,000/µL, and WBC count 6,000/µL. For the dialysis catheter insertion she needs a transfusion of RBCs.

What special processing or attributes of the RBC unit are most appropriate?

A. Leukocyte reduced, cytomegalovirus (CMV) seronegative

B. Phenotype matched, saline washed

C. Leukocyte reduced, plasma volume reduced

D. Leukocyte reduced, saline washed

E. Phenotype matched, irradiated

**Explanation**

With storage, RBC units develop increased extracellular K+ and free Hb and decreased 2,3-diphosphoglycerate (causing increased RBC affinity to oxygen and decreased oxygen release to tissue), intracellular pH, and nitric oxide. To avoid worsening hyperkalemia in someone with anuria and renal failure, all the extracellular K+ in stored RBCs should be removed before transfusion by saline washing. Alternatively, a freshly collected RBC unit can be provided, because extracellular K+ increases most in the first 7 days of storage.

Leukocyte reduction decreases risk of HLA alloimmunization and transfusion-transmitted CMV. Transfusion from a CMV-seronegative donor decreases risk of transfusion-transmitted CMV. Plasma volume reduction removes most of the plasma in a unit, but RBC units already have very little plasma to begin with. Phenotype matching prevents RBC alloimmunization, which is rare in young children. Irradiation prevents transfusion-associated graft-versus-host disease in patients who are T-cell immunocompromised or those receiving transfusions from close relatives.

4. A 16-year-old girl treated for relapsed acute lymphoblastic leukemia (ALL) has a platelet count of 6,000/µL. After a platelet transfusion, the 1-hour posttransfusion platelet count is 7,000/µL. A second platelet unit is ordered, and the 1-hour posttransfusion platelet count is 7,000/µL.

What is the correct next step in the management of this patient?

A. Assess the patient clinically for potential causes of platelet consumption and order an HLA antibody screen.

B. Order another platelet count immediately.

C. Assess the patient clinically for potential causes of platelet consumption and order a platelet-specific alloantibody test, such as anti-HPA-1a antibody testing.

D. Order a third platelet transfusion, ensuring it is an apheresis product.

E. Obtain CT scan of the abdomen to look for splenomegaly.

**Explanation**

Although the case does not tell you all the information that is needed to finalize the diagnosis of HLA alloimmunization–induced platelet transfusion refractoriness, the 1-hour posttransfusion platelet counts strongly suggest this diagnosis. The causal antibodies in this setting are almost always directed at HLA class I antigens that are found on the platelet surface and not platelet-specific antibodies. Patients with significant HLA alloimmunization are found to have HLA antibodies that are reactive against more than 20% (and often more than 80%) of the population. The stimulus that causes HLA alloimmunization is exposure to foreign tissues either through pregnancy, transfusion, or transplantation. The HLA antibody test also is called a panel reactive antibody (PRA) or a calculated PRA (cPRA). In this test, the laboratory communicates the percentage of the population’s HLA types that the patient has formed antibodies against. It gives a good idea of how difficult it will be to find a platelet unit that the patient will not have alloantibodies against (patients with 95% cPRA will be predicted to be incompatible with 95% of HLA types). Discussing the case with the transfusion service medical director to get ready to find HLA-matched or platelet crossmatch-compatible platelets would be very helpful. Ensuring there is not another reason for platelet consumption, such as sepsis, splenomegaly, or disseminated intravascular coagulation, is also important. Lastly, other means to protect the patient from bleeding, such as an antifibrinolytic, should be considered.

Ordering another platelet count immediately is unlikely to yield helpful data. Giving the patient another platelet transfusion from a random (non–HLA-matched) donor will probably elicit no improvement in the platelet count. CT scan of the abdomen entails radiation exposure, and hepatosplenomegaly alone is an unlikely cause of this patient’s transfusion refractoriness.

5. An 8-year-old boy with sickle cell (HbSS) disease presents to your emergency department with back pain and increased scleral icterus. He was inpatient 9 days ago for acute chest syndrome, received 1 unit of RBCs, and was discharged with Hb of 10 g/dL. Today, Hb is 6 g/dL, reticulocyte count is less than 3%, and direct antiglobulin test (DAT) is 3+ for IgG. Eluate of the DAT-positive cells was positive for anti-Fya.

What is the most likely diagnosis?

A. Delayed hemolytic transfusion reaction due to ABO incompatibility of recently transfused RBCs

B. Delayed hemolytic transfusion reaction due to RBC alloantibody formation triggered by recent transfusion

C. Vaso-occlusive pain crisis with increased sickle cell–associated hemolysis

D. Vaso-occlusive pain crisis with acute parvovirus infection

E. Acute hemolytic transfusion reaction due to minor RBC antigen/antibody incompatibility of recently transfused RBC

**Explanation**

This is a classic presentation for delayed hemolytic transfusion reaction (DHTR) in a patient with sickle cell disease. DHTRs usually occur within 3 to 10 days of a transfusion and may be due to de novo or anamnestic RBC alloantibody formation. Signs and symptoms include fever, jaundice, back pain, and hemoglobinuria. Positive DAT with eluate that is positive against an RBC antigen that the patient is negative for completes the classic clinical picture. DHTRs in patients with sickle cell disease can trigger a condition called hyperhemolysis, in which post-transfusion Hb is lower than pretransfusion Hb and there is reticulocytopenia. Because pain can be a symptom, DHTR may be confused with pain crisis, so a good transfusion history is important.

ABO incompatibility will cause immediate hemolysis, which is an acute, not delayed, hemolytic transfusion reaction. Vaso-occlusive pain crisis with increased sickle hemolysis will not cause positive DAT or reticulocytopenia. Although reticulocytopenia may be from parvovirus infection, this does not explain the positive DAT and increased jaundice. Acute hemolytic transfusion would be considered if the hemolysis occurred during or just after RBC transfusion.

6. A 16-year-old African American girl with sickle cell (HbSS) disease is being treated by you for worsening acute chest syndrome (ACS), with increasing oxygen requirement and Hb 6.4 g/dL. She has received 10 previous RBC transfusions for ACS, splenic sequestration, and aplastic crisis. Her latest RBC transfusion was 1 year before this admission. She has a previously identified alloantibody against the red cell E antigen. The patient’s ABO and RhD type is identified, and indirect antiglobulin test of patient’s plasma/serum is performed against 3 to 4 screening reagent RBCs. This screen is negative for antibodies, including anti-E.

What additional testing would the blood bank perform to identify the appropriate RBC unit for transfusion?

A. A random RBC unit is selected, and the patient’s plasma/serum sample is mixed with a sample from this unit; if agglutination does not occur, this crossmatch-compatible unit is issued for transfusion.

B. An E-negative donor RBC unit is selected and issued for transfusion.

C. An E-negative donor RBC unit is selected, and the patient’s plasma/serum sample is mixed with a sample from this unit; if agglutination occurs, this unit is issued for transfusion.

D. O RhD-negative RBCs are selected from inventory and immediately issued for transfusion.

E. An E-negative donor RBC unit is selected, and the patient’s plasma/serum sample is mixed with a sample from this unit; if agglutination does not occur, this crossmatch-compatible unit is issued for transfusion.

**Explanation**

The following describes blood bank procedure for providing RBCs to someone with previously identified RBC alloantibody when RBC transfusion is ordered:

1. Patient’s ABO and RhD type are identified.

2. Indirect antiglobulin test of patient’s plasma/serum against 3 to 4 screening reagent RBCs, which screens for unexpected, clinically significant alloantibodies of the IgG type that can cause hemolysis. If the screen reveals a positive reaction with any one of the reagent cells, the test is positive, and the antibody specificity must be determined to correctly select donor RBC units for crossmatching.

3. Antigen-negative donor RBC units are selected, and the patient’s plasma/serum sample is mixed with samples from these units and checked for RBC agglutination; this is the crossmatch. The RBC units chosen have to be negative for antigens to which the patient currently or historically has antibodies, the latter even if the antibody screen is currently negative.

4. If agglutination does not occur, the crossmatch-compatible unit is issued for transfusion. If agglutination occurs, the unit is labeled crossmatch-incompatible and should not be transfused to this patient.

7. A 12-year-old girl with known idiopathic thrombocytopenic purpura presents with headache and visual field loss. Platelet count is 3,000/µL, and head CT shows a 3-cm hematoma in the parietal lobe. Patient’s blood type is A Rh-negative. She has received high-dose steroids but needs a platelet transfusion for emergent splenectomy and craniotomy. The blood bank calls you to say that there is an extreme platelet shortage and there are no Rh-negative platelets in the city.

What is the best way to manage this patient’s transfusion?

A. Wait to transfuse this patient despite active bleeding because you cannot transfuse Rh-positive platelets to an Rh-negative girl.

B. Transfuse Rh-positive platelets, because the present risk of bleeding outweighs the future risk of fetal complications.

C. Transfuse volume-reduced Rh-positive platelets to reduce risk of RhD sensitization.

D. Transfuse Rh-positive platelets, then administer Rh immune globulin within 1 week of the transfusion to prevent RhD alloimmunization.

E. Transfuse Rh-positive platelets, then administer Rh immune globulin within 72 hours of the transfusion to prevent RhD alloimmunization.

**Explanation**

Although platelets do not have RhD antigens, transfusion of platelets from RhD-positive donors can induce formation of anti-D in patients because of residual RBCs in platelet units, regardless of the method of collection (whole blood–derived platelets have less than 0.5 mL per unit, and single-donor pheresis platelets have far less). In female patients with childbearing potential, RhD alloimmunization could cause hemolytic disease of the fetus and newborn. To avoid RhD sensitization, Rh immunoglobulin (one vial per 15 mL RBCs) should be administered within 72 hours of exposure.

8. A healthy term 15-hour-old infant with blood type A Rh-positive was born to a G1P1 mother whose blood type is O Rh-negative. Total bilirubin is 10 mg/dL, and DAT for IgG is 3+ positive.

Which antibody was identified on the eluate?

A. Anti-D IgM

B. Anti-A,B IgG

C. Anti-A IgM

D. Anti-d IgG

E. Anti-K IgM

**Explanation**

Anti-A,B is an IgG antibody found in people with O blood type. Because of its size, it can easily cross the placenta and cause hemolysis of fetal RBCs that have A or B antigens. IgM antibodies are too large to cross the placenta. There is no such thing as anti-d antibody because there is no d allele on RBCs; D-negative people are those who lack the D allele.

9. A 16-year-old girl presents with petechiae and sleepiness after new-onset generalized seizure. The emergency department calls you because her Hb is 7 g/dL, platelet count 15,000/µL, and WBC count 4,500/µL. Reticulocyte count is 7%, direct antiglobulin test is negative, and blood smear shows schistocytes. Creatinine is 1 mg/dL.

What is the most appropriate management for this patient?

A. Transfusion of fresh frozen plasma, 20 mL/kg

B. Therapeutic plasma exchange, replacement using 5% albumin

C. Therapeutic plasma exchange, replacement using fresh frozen plasma

D. Therapeutic plasma exchange, replacement using 5% albumin and cryoprecipitate

E. Transfusion of cryoprecipitate-poor plasma, 20 mL/kg

**Explanation**

This patient meets criteria for thrombotic thrombocytopenia purpura (TTP)—microangiopathic hemolytic anemia and thrombocytopenia. The classic TTP presentation includes mental status change, fever, and uremia. Microangiopathy is represented by the presence of schistocytes in the blood smear. Although low levels of the von Willebrand factor (vWF)-cleaving metalloprotease ADAMTS-13 are associated with acquired TTP, it remains a clinical diagnosis. Untreated, TTP is almost always fatal, so emergent treatment should be started as soon as possible, even if the diagnosis is not definitive. Early therapeutic plasma exchange using fresh frozen plasma or cryoprecipitate-poor plasma for replacement is the standard of care.

Cryoprecipitate-poor plasma is plasma that is left after manufacturing cryoprecipitate and is lacking in fibrinogen, factor 8, vWF, factor 13, and fibronectin. Simple transfusion of plasma or cryoprecipitate-poor plasma may be necessary for patients for whom there may be delay in starting therapeutic plasma exchange (or who have congenital TTP), but transfusion is not definitive therapy for acquired TTP. Neither 5% albumin nor cryoprecipitate contains ADAMTS-13.

10. A 4-year-old girl with meningococcemia has started oozing from IV sites. Hb is 8.5 g/dL, WBC count is 3,500/µl, ANC is 200/µL, platelet count is 70,000/µL, PT is 18 seconds, PTT is 75 seconds, and fibrinogen is 100 mg/dL. Appropriate antibiotics have been started, and the patient is otherwise stable.

Which of the following is the most appropriate next step?

A. Transfuse RBCs 10 to 15 mL/kg over 4 hours, which should increase Hb by 2 to 3 g/dL.

B. Transfuse granulocytes, 1 unit from a G-CSF-stimulated donor, daily until ANC exceeds 500/µL.

C. Transfuse platelets, ½ single-donor pheresed unit, which should increase platelet count by 30,000-50,000/µL.

D. Transfuse fresh frozen plasma, 20 mL/kg, which should correct both procoagulant and anticoagulant factor deficiency.

E. Transfuse cryoprecipitate, 1 unit per 10 kg body weight, which should correct fibrinogen level to normal.

**Explanation**

This patient has disseminated intravascular coagulation (DIC), which entails consumption of both procoagulant and anticoagulant factors and may cause both thrombosis and bleeding. In this case, the cause of DIC is meningococcal infection, which may be associated with purpura fulminans. Because of the risk of thrombosis, even in the face of bleeding, balanced replacement of procoagulant and anticoagulant factors, which are all present in fresh frozen plasma, is most appropriate. Although fibrinogen replacement is best accomplished by cryoprecipitate transfusion, this product is very prothrombotic because, aside from fibrinogen, it contains factor 8, von Willebrand factor, and fibronectin.

The pediatric dosing of the different blood products are correct above. However, RBCs, granulocytes, and platelets are not indicated for the patient at this time.

11. A 17-year-old boy with relapsed acute myeloid leukemia is referred to your center for hematopoietic stem cell transplantation. Platelet count is 6,000/µL, so you decide to give a platelet transfusion. In your center, only single-donor pheresis (SDP) platelets are given, but he came from a center where only whole blood (WB)-derived platelets are used, so the family is concerned about the difference.

Which of the following is a correct statement about platelet units?

A. SDP platelets and WB-derived platelets must be constantly agitated and stored at 4 °C.

B. WB-derived pooled platelets come from one blood donor.

C. SDP platelets are less likely to cause allergic transfusion reactions.

D. Both platelet types can be stored for 10 days and are suspended in the donor plasma.

E. SDP platelets and WB-derived platelets are both tested for bacteria, sometimes using different methods.

**Explanation**

SDP platelet units are collected by apheresis from a donor who may donate up to 3 units per donation and should contain more than 3 × 1011 platelets. WB-derived platelets are derived from WB donations after centrifugation and should contain 5.5 × 1010 platelets. Because both products are stored at room temperature (22 °C to 24 °C), risk of bacterial growth is significant, so all platelet products are tested for bacteria before release from the blood bank by culturing a small aliquot of the product or with a rapid immunoassay.

WB-derived platelets from several donors usually are pooled to get the appropriate platelet dose. SDP and WB-derived platelets have similar rates of allergic reaction because these are both stored in donor plasma. After collection, SDP and WB-derived platelets can be stored for 5 to 7 days.

12. A 6-year-old boy with factor XI deficiency (30%) and blood type A is scheduled to have elective tonsillectomy and adenoidectomy. At the ENT’s office, the surgeon asks the family whether they would like to directly donate blood for the surgery and sends the parents to the local blood supplier so the father can donate blood for his son.

What are the main concerns with the use of directed family blood donors?

A. The blood type of the father may be incompatible with the child. The risk of transfusion-transmitted viral illness is lower in directed family donors.

B. The blood type of the father may be incompatible with the child. The risk of transfusion-transmitted viral illness is higher in directed family donors. Irradiation of the products is not needed.

C. The blood type of the father may be incompatible with the child. Irradiation of the products is not needed.

D. The blood type of the father may be incompatible with the child. The risk of transfusion-transmitted viral illness is higher in directed family donors. Irradiation of the products is needed.

E. The blood type of the father is likely to be compatible with the child. The risk of transfusion-transmitted viral illness is lower in directed family donors. Irradiation of the products is needed.

**Explanation**

Although directed family donation often is viewed by the public as a safer option for a family member, there are a number of concerns to keep in mind. First, directed donors may not be ABO compatible for the product they want to donate, leading to emotional distress of a family that already is facing healthcare challenges. Second, first-time donors and directed donors have a higher rate of being deferred for positive viral testing. All family donor blood products must be irradiated to decrease the risk of transfusion-associated graft-versus-host disease. Lastly, if the patient is destined for a hematopoietic stem cell transplant in the future, the patient may form HLA antibodies to that family member’s HLA antigens, making them less suitable to be a stem cell donor in the future. Repeat, volunteer blood donors are the safest approach for transfusion for this patient.

13. Twenty days after cord blood transplant for acute myeloid leukemia, a 10-year-old girl develops an *Aspergillus* lung infection, confirmed by lung biopsy. Her clinical status worsens despite standard antifungal therapy, and she remains neutropenic, with total WBC count consistently less than 500. She continues to be cytomegalovirus (CMV) seronegative.

Which of the following is most appropriate type of granulocyte to order?

A. ABO crossmatch-compatible, leukocyte-reduced, irradiated, and CMV seronegative

B. ABO crossmatch-compatible, irradiated, and CMV seronegative

C. Irradiated and CMV negative

D. Leukocyte reduced, irradiated, and CMV seronegative

E. Leukocyte reduced (and therefore CMV safe) and irradiated

**Explanation**

All granulocytes are collected by apheresis from donors who have been stimulated with either steroid or steroid plus G-CSF. With apheresis, there is a large volume of RBCs contaminating the product, so the ABO type must be compatible to prevent hemolytic transfusion reaction. Furthermore, the number of RBCs contaminating the product can be so great that the hemoglobin level in the patient can rise, sometimes by 1 to 2 g/dL, after transfusion, especially in smaller children. The granulocyte product should be transfused within 24 hours of collection and stored at room temperature. If possible, when transfusing the product, the transfusion should be 8 to 12 hours spaced apart from the antifungal therapy amphotericin. The product definitely should be irradiated because there are many T-cells from the donor in the product that could cause transfusion-associated graft-versus-host disease in the patient. Finally, the product cannot be leukocyte reduced because WBCs cannot be eliminated; therefore, monocytes in the product, which can contain CMV in a previously infected donor, could transmit CMV to a CMV-naive immunocompromised recipient.

14. A 13-year-old boy with osteosarcoma is undergoing his first RBC transfusion. Oxygen saturation before transfusion was 97% on room air. After receiving 43 mL of the blood product, the patient is feeling lightheaded and complains of a gagging feeling and difficulty breathing. Blood pressure drops to 86/48 mm Hg, oxygen saturation drops to 85%, and his upper eyelids are swollen. The blood transfusion is stopped. He is treated with oxygen supplementation, normal saline bolus, albuterol, antihistamines, and epinephrine. After about 40 minutes he has returned to baseline, including his oxygen needs. The initial transfusion reaction evaluation shows a negative direct antiglobulin test and no visual evidence hemolysis of his post-transfusion blood sample.

What type of transfusion reaction did this patient experience, and how should subsequent transfusions be managed?

A. This is a febrile nonhemolytic transfusion reaction; antipyretics should be used before the next transfusion.

B. This is a possible septic transfusion reaction; the product and patient should be cultured, and he should not need anything different for the next transfusion.

C. This is a mild to moderate allergic transfusion reaction; the patient should receive future transfusions only after premedication with antihistamines.

D. This is a potential transfusion-related acute lung injury; the product should be tested for HLA antibodies, and the patient should not need anything different for the next transfusion.

E. This is a severe allergic transfusion reaction, or anaphylaxis. Because of the severity, it is prudent to consider washing red cell and platelet units for future transfusions. Premedication also may be considered.

**Explanation**

This patient suffered an anaphylactic (severe allergic) transfusion reaction. These reactions are mediated through the patient’s IgE and directed at antigens in the blood product plasma (donor plasma), which causes mast cell degranulation and histamine release. Most allergic transfusion reactions are sporadic and not necessarily recurrent; however, in some patients recurrent allergic transfusion reactions appear to be related to patient factors and not product factors. Because this was his first transfusion, it is particularly concerning that he could have additional reactions. Using washed cellular blood products (platelets and RBCs) is an effective way to remove donor plasma and prevent future reactions, although these processing steps lead to platelet activation and cell loss in the product. Discussion with the transfusion services medical director would be prudent; because the reaction was severe, it is possible that the patient has IgA deficiency with anti-IgA antibody and that the allergy is severe and plasma transfusion will be an issue in the future. Further testing and planning are warranted.

The clinical scenario does not describe a febrile or septic reaction. Transfusion-related acute lung injury is much lower on the differential because that diagnosis is based on acute hypoxic respiratory failure without evidence for other causes. This patient had several findings highly suggestive of an allergic mechanism.

15. A 4-year-old girl with acute lymphoblastic leukemia is admitted for pancytopenia and fever. Platelet count is less than 10,000/mm3. The patient’s blood type is A+. The blood bank is low on platelet inventory and can only dispense O+ platelets.

Which of the following is the best platelet product to prepare and transfuse to this patient?

A. 10 mL/kg of O+ single-donor platelets that are prestorage leukocyte reduced and irradiated

B. 10 mL/kg of O+ single-donor platelets that are volume reduced, prestorage leukocyte reduced, and irradiated

C. Delayed transfusion despite active bleeding because it is unsafe to transfuse O+ prestorage leukocyte-reduced and irradiated single-donor platelets to an A+ child

D. 10 mL/kg of O+ single-donor platelets that are irradiated only

E. 10 mL/kg of O+ single-donor platelets that are volume reduced and irradiated

**Explanation**

This patient needs a platelet transfusion. However, administering O platelets to an A-group patient without knowing the titer of the anti-A isohemagglutinin is unacceptable. The plasma accompanying type O platelets can contain both anti-A and anti-B isohemagglutinins and can result in severe hemolysis in a recipient. There have been three reported pediatric deaths in the literature with the administration of “out-of-ABO group” platelets. Thus, in pediatric hospitals, volume reduction (removal of most of the plasma surrounding the platelets) or washing of the unit (removal of all plasma surrounding the platelets with resuspension in normal saline) can be performed. Each of these procedures can harm the platelets by activating them, thereby damaging or dampening the platelet product or its effectiveness. In addition, both procedures can take up to 2 hours to be prepared in the blood bank, thus delaying transfusion of the product. Products that are washed have a 4-hour expiration period (from processing in an open system), with an increased risk for bacterial contamination, necessitating immediate transfusion after issuance.

Prestorage leukocyte reduction prevents HLA alloimmunization and transfusion-transmitted cytomegalovirus. Irradiation prevents transfusion-associated graft-versus-host disease and is indicated for potentially immunocompromised recipients.