The Leukemia & Lymphoma Society®
Fighting Blood Cancers

Blood Transfusion

LEUKEMIA | LYMPHOMA | MYELOMA

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Introduction

This booklet provides information about blood transfusion for patients with leukemia, lymphoma or myeloma (blood cancers) and their families. We welcome your comments on the booklet.

Each year, more than 15 million units of whole blood are collected and nearly five million patients are transfused with blood components in the United States. (Source: The National Blood Data Resource Center 2001, the most recent year for which data are available.) On average, each unit is divided into three different components: red cells, platelets and plasma. Most of the red cells are transfused to patients undergoing surgical procedures. However, patients with blood cancers frequently receive platelets and some red cells. They may require more blood components overall than surgical patients because their need is likely to continue over a number of weeks or longer. In addition, most patients who undergo marrow or blood stem cell transplantation will be transfused.

The most frequently asked questions about blood transfusion relate to:

- The safety of the blood supply;
- Diseases that can be transmitted by blood components; and
- Other complications that may occur following blood transfusion and what is being done to reduce those risks.

These questions are answered in this booklet.

The Blood

The blood is the main transport system in the body. It carries raw materials and finished products from where they originate to where they are used and transports waste products to disposal sites. Some of the contents are traveling to a specific destination. For example, sugar (glucose) may be going from the liver to muscle to provide a source of energy for movement; coagulation factors may be carried from the liver to a cut blood vessel to ensure clotting. Other contents are integral parts of blood, such as the red cells and platelets that perform their functions and spend their mature existence in the blood.

The blood accounts for about 7 percent of the body weight of a normal adult. This means that a 154-pound person (70-kilogram average-sized person) has about 10 pints (or 5 liters) of blood. Smaller adults and children have proportionately smaller blood volumes. Blood contains red cells, different types of white cells and platelets. These components are suspended in the liquid part of blood, called plasma.

Red Cells

The red cells make up about half the volume of blood. They are very specialized cells that are composed of a disc-like envelope that contains the red-colored protein hemoglobin, which gives the blood its characteristic color. Hemoglobin is the protein that picks up oxygen in the lungs and delivers oxygen to the tissues. It also carries carbon dioxide from the tissues to the lungs, to be exhaled. The normal red cell lives for 120 days in the circulation, and so about 1 percent of the body's red cells (about half an ounce) must be replaced by the bone marrow each day. The red cell membrane is composed of protein, fats and carbohydrate molecules that are associated with the various blood groups. The ABO blood group was described in 1900

and the Rh blood group in 1945. Transfused red cells should match the patient's ABO and Rh blood groups. Many other blood group antigens have since been described. However, these are not usually matched for transfusion unless the patient has developed antibodies to these antigens as a result of previous pregnancies or blood transfusions.

Platelets

The platelets are small fragments of cells that help stop bleeding from damaged blood vessels. They are present in high concentration in the blood and circulate for only about 10 days. That means that 10 percent of them are replaced each day to maintain the platelet count at normal levels. Platelets function in two ways. One is to stick to damaged surfaces of small blood vessels and literally plug up any holes that may develop. For example, when someone has a cut, the blood vessels that carry blood are torn open. Platelets stick to the torn surface of the vessel, clump together, and plug up the bleeding site. A firm plug follows. In time, the plug is dissolved and the vessel wall is repaired and returns to its normal state. The second function of platelets is to provide a surface that promotes blood clotting.

White Cells

The white cells include neutrophils, eosinophils, basophils, monocytes and lymphocytes. Neutrophils and monocytes serve as the major defense against invading bacteria and fungi. They are really tissue cells but because they are made only in the marrow, they use the blood as a rapid transit system to carry them to sites of infection. Unlike red cells and platelets, the white cells are capable of leaving the blood and moving into the tissues where they can ingest, or eat, bacteria or fungi. This kills the organisms and helps cure the infection. The neutrophils survive for short periods, less than a day or two, and thus must be replaced quickly by new cells delivered from the marrow. Eosinophils and basophils are two additional types of white cells whose roles are to participate in allergic reactions.

The lymphocytes are part of the immune system. Most of the lymphocytes in the body are found in the lymph nodes, the spleen, and a few other lymphoid organs. They move from one lymphatic organ to another by means of the lymphatic channels and the circulation. About one billion new lymphocytes are made each day. There are three major types of lymphocytes: T cells, B cells and natural killer cells. They make up a complex immune system that responds to foreign organisms and helps fight cancer.

Plasma

The plasma is the liquid portion of blood that is free of cells. It is composed primarily of water, in which many chemicals and gases are dissolved. In addition, there are minerals, carbohydrates, fats, and specialized molecules such as vitamins, hormones, and enzymes. Plasma also contains specialized components such as coagulation factors and gamma globulin, which contains antibodies. Coagulation factors can be removed from plasma and may be used to treat people with coagulation factor deficiencies, such as hemophilia. Gamma globulin can be concentrated from plasma and can be used to help people who lack immune globulins fight infection.

Bone Marrow

Marrow is the spongy tissue where blood cell development takes place. It occupies the central cavity of bone. All bones have active marrow at birth. By the time a person reaches young adulthood, the bones of the hands, feet, arms and legs no longer have functioning marrow. The backbones (vertebrae), hip, shoulder bones, ribs, breast bones and skull contain marrow that makes blood cells.

The process of blood formation is called hematopoiesis. Stem cells are a small group of cells that are responsible for making all the blood cells in the marrow. Stem cells eventually develop into specific blood cells by a process

of differentiation. When the fully developed and functional cells have been formed, they leave the marrow and enter the blood. In healthy individuals there are sufficient stem cells to keep producing new blood cells continuously. Some stem cells enter the blood and circulate. They are present in such small numbers that they cannot be counted or identified by the usual blood tests. Their presence in the blood is important, because they can be collected by special techniques called hemapheresis and used for transplantation in place of stem cells from marrow. This circulation of stem cells from marrow to blood and back again occurs in the fetus as well. That is why, after birth, placental and umbilical cord blood can be used as a source of stem cells for transplantation.

In summary, blood cells are made in the marrow, and when the cells are fully formed and able to function, they leave the marrow and enter the blood. The red cells and the platelets perform their respective functions of delivering oxygen and plugging up injured blood vessels in the circulation. The neutrophils, eosinophils, basophils, monocytes and lymphocytes, which together make up the white cells, move into the tissues (for example, the lungs), where they can combat infections such as pneumonia and perform their other functions.

Preparing Blood Components

More than 98 percent of the blood supply in the U.S. comes from volunteer donors. Most donors give a single unit of whole blood at a site convenient to their work or home. The availability of plastic containers that can have one or more satellite bags attached in a completely sterile system allows for flexibility in preparing the donated blood. Usually three or four blood components such as red cells, platelets, plasma and cryoprecipitate are gained from each unit of whole blood donated. "Cryoprecipitate" is the name for the blood component obtained by freezing plasma and then thawing it at 4°C. It is used to provide certain clotting factors for people who need them due to a genetic or acquired defect. The usefulness of component therapy is that each patient is given only the specific component that he or she needs. This allows one donation to benefit up to four patients and conserves precious blood resources. Each component has to be prepared within a certain time from collection and stored at a specific temperature and length of time to maintain optimum function. The availability of plastic bags with attached satellite bags that can be centrifuged in the lab makes it possible to separate out a variety of different components. The primary blood bag contains an anticoagulant that prevents the blood from clotting after it has been collected. This unit is spun gently in the lab using a centrifuge, which settles the heavier red cells to the bottom of the bag. The lighter plasma that also contains the platelets can then be siphoned off into one of the attached satellite bags. A preservative is then added to the red cells, the tubing is sealed and the red cells are separated from the other bags. A red cell unit is about 250 milliliters (about 10 ounces) and is stored at 4°C for 42 days. Ideally, the red cells transfused are the same ABO and Rh type as the patient's. Certain exceptions are made in emergencies.

The bag containing the platelet-rich plasma is then centrifuged at a higher speed to deposit the platelets at the bottom of the bag along with about 50 milliliters (about two ounces) of plasma. Most of the plasma is siphoned into a third attached bag. The unit of platelets is sealed and separated, leaving a bag of plasma. Platelets need to be stored in an incubator at room temperature and rocked gently. They have a shelf life of only 5 days. About 4 to 5 platelet units of the same ABO type as the patient are pooled together to make a platelet transfusion for an adult. One unit may be sufficient for an infant. Cryoprecipitate can be made from the plasma or the plasma can be stored in a freezer for a year. During this time, it may be used for transfusion or processed further.

In addition to whole blood donations, some components, such as platelets or granulocytes, can be collected by hemapheresis. With hemapheresis, a healthy donor comes into the blood center and his or her blood is drawn into a machine where the blood is separated into its components. The cell separator collects only the part of the blood that is needed by the patient and the rest of the blood is returned to the donor. This allows a much larger amount of a blood component to be harvested from a single donor. Also, the donor can be specifically selected or matched with the patient and the donor can donate more frequently because he or she does not lose red cells.

Safety of Blood Transfusions

Autologous and Directed Donations

Autologous donation, in which the patient donates up to 3 units of his or her own blood to be re-infused later, is possible for healthy patients who are undergoing a one-time surgery. However, for patients who are being treated for leukemia, lymphoma or myeloma such donations are not possible because their own blood lacks adequate numbers of cells.

Some family members ask about "directed donations" in which the family chooses their own donors for the patient, believing this may be safer. Although this is possible if a small number of red cells are to be used, e.g., for a surgical procedure, there is no evidence that these donations are any safer than the general blood supply. In fact, under certain circumstances they may be less safe because related individuals or friends may not wish to expose a circumstance that makes them unsuitable for donation. For patients such as those with leukemia, lymphoma or myeloma, the need for long-term blood support and for specialized components usually makes this approach unfeasible. Moreover, the consequences of these severe diseases usually outweigh the concern about blood safety in medically advanced countries.

Donor Screening and Collection

Every patient and physician is concerned about the safety of the blood supply. The risk of transmitting viral diseases such as HIV and hepatitis by blood transfusion had dropped dramatically in the last 25 years. This is the result of a multilayered approach to safety. First, a voluntary blood donor pool eliminates individuals who might donate for money and not be honest about their health history. Public education is important so that people know that certain diseases can be transmitted by blood, what the risk factors are for carrying infectious agents, and who should refrain from donating because

they are not suitable donors. All potential donors receive written information to encourage them to defer themselves if they are at risk of transmitting a disease through their blood. Once a donor comes to a blood donation site, he or she is screened by trained personnel using a very detailed medical history coupled with a pertinent physical examination. This ensures that the procedure will be safe both for the donor and the blood recipient. A call-back procedure also allows donors to indicate, in a confidential manner, if their unit is not suitable for transfusion.

Blood is collected using a new sterile needle and bag after a meticulous cleaning of the donor's arm. Needles are never reused, so there is no risk of infections being transmitted to the donor. Extra tubes of blood are drawn for the laboratory testing. All units are checked for their ABO and Rh blood type and to ensure there are no red cell antibodies in the donor's plasma that might injure the patient's red cells.

Testing for Carriers of Infectious Disease

Prior to 1985, donated blood was tested only for syphilis and hepatitis B. Today, 12 tests for seven infectious diseases are performed on each unit. These tests have steadily been made more sensitive over the years. Most of these are indirect tests that detect antibodies against the infectious disease. They include antibodies to syphilis, human immunodeficiency virus-1 (HIV-1) and HIV-2, hepatitis B virus core antigen, hepatitis C virus, and human T lymphocytotropic viruses (HTLV-1 and HTLV-2). In addition, tests are performed for hepatitis B virus surface antigen, the protein coat of the hepatitis B virus. Sometimes additional testing is needed, such as for cytomegalovirus (CMV) antibodies.

In mid-1999, nucleic acid testing for HIV and hepatitis C was added to the current testing. This is a highly sophisticated and sensitive means of detecting the actual virus rather than relying on the development of an antibody in the donor. These tests have further reduced the chance of transmitting hepatitis C or HIV. The current estimates for the risk of transmitting HIV or hepatitis C through blood transfusion is one in two million transfusions for each virus. The estimated risk for hepatitis B is one in 200,000 transfusions. The risk for HTLV-1 is estimated at one in 3 million transfusions. Recently, a similar test was introduced for the West Nile virus.

Decreasing the Risk of Transmitting Viral Infections

Much research is being focused on methods to inactivate viruses in blood components. Some coagulation factors, such as factors VIII and IX, are made from plasma and can be heat-treated to inactivate viruses that might have been present in plasma. Fresh frozen plasma can also now be processed by a technique called solvent detergent treatment, which will eliminate viruses such as HIV, and hepatitis B and C viruses. These viruses have fatty membranes that are destroyed by the detergent. Coagulation factors are manufactured from pools of 1,500 donated units. These products are treated by inactivation techniques and thus are not infectious for these viruses. It is expected that similar technology may become available for a single unit of plasma, further decreasing the risk of viral contamination.

Blood cells are fragile, and the plasma in which they are suspended cannot be virally inactivated by harsh procedures such as detergent treatments. However, research is underway to look at more gentle techniques that could be used for virally inactivating red cells and platelets.

Removing White Cells

White cells contaminate the red cell and platelet components. These cells are of no use to the patient and are associated with many reactions during and after transfusion. The standard blood filter does not remove such small cells. However, special filters have been developed that can remove up to 99.99% of these cells. The technical term for the process of removing white cells, also called leukocytes, from blood components is "leukoreduction." This process used to be done at the bedside as the blood was being given to the patients. Now that removal of white cells is more common, white cell reduction is often done at blood centers at the time the components are prepared. This ensures that the filtering is consistent and components can be tested to ensure that white cell reduction has been achieved. In many industrialized countries, removal of white cells from red cell or platelet components is now standard practice. In the U.S., leukoreduction is frequently used but it is not universal. Patients requiring transfusion should ask their physician about the use of leukoreduced blood components.

Transfusions for Patients with Leukemia, Lymphoma or Myeloma

This section contains information that applies to leukemia, lymphoma, myeloma and other hematological conditions, such as hereditary anemias and aplastic anemia. In particular, blood or marrow stem cell transplants for treatment of these diverse diseases invariably involves frequent blood transfusions. This occurs because the basis of the transplant therapy is to give very high doses of chemotherapy to the patient to maximize the chance of a cure. Many drugs used for chemotherapy cause temporarily impaired blood cell production in the marrow and depressed immune system functions.

The disease processes of leukemia, myeloma, and many lymphomas interfere with the normal production of red cells, white cells, and platelets in the marrow. Thus, it is common for patients with these diseases to develop anemia (low red cells) and thrombocytopenia (low platelets), and in some cases, leukopenia (low white cells, either granulocytes or lymphocytes or both). This can happen before treatment begins because the cancer cells inhibit the production of normal blood cells in the marrow. In addition, the drugs used to treat these diseases and which stop the progression of or, in some cases, cure these diseases, often injure healthy stem cells in the marrow as a side effect. These precursor cells normally go on to produce red cells, white cells or platelets. This injury to normal cells can cause temporary side effects such as very low red cell or platelet counts for a period of a few weeks, in most cases.

During and after chemotherapy it is possible to replace the red cells and platelets by cells donated by healthy volunteers in the form of blood transfusions. Severe anemia (a relative term, not well defined by scientific

studies) or thrombocytopenia can be life-threatening in extreme cases. Most doctors specializing in the care of patients with blood cancers believe that varying degrees of replacement by prophylactic red cell transfusion represent a good practice to prevent complications of anemia, such as fatigue, weakness, shortness of breath, or in extreme cases, heart attack or stroke. Similarly, most physicians advocate giving prophylactic platelet transfusions to reduce the likelihood of bleeding.

Unfortunately, practical methods of safely and effectively transfusing adequate numbers of granulocytes or other white cells are not yet available to prevent infection that occurs as a result of low white cell count. White cell transfusion is usually reserved for uncommon instances of severe infections with bacteria or fungi that do not respond to antibiotics or anti-fungal drugs. Because the yield of white cells from current collection techniques is insufficient, some investigative studies and clinical protocols now involve administering white cell growth factors (e.g., G-CSF) to volunteer donors, particularly family members, prior to white cell collection by hemapheresis. This increases the number of white cells that are in the donor's circulation, thus improving the yield of white cells collected. It is hoped that the larger number of white cells collected in this manner will be more effective in fighting infection.

The need for transfusions varies depending on the type of blood disease in question and the type of drugs used in the chemotherapy. For example, almost all patients with leukemia (a disease primarily affecting the marrow and blood) require some transfusions during their care. Many patients with Hodgkin or non-Hodgkin lymphoma (diseases primarily affecting the lymph nodes and spleen) may not require transfusions unless they require a blood or marrow stem cell transplant or if the lymphoma involves the marrow.

Individual physicians take different approaches in deciding if transfusion is appropriate for a given patient because there is controversy as to how to best balance the benefits and risks of transfusion in many clinical situations. Studies comparing various indications for transfusions may help physicians have a more scientific basis for their decisions, but currently transfusion policies usually depend on the patient's condition and an individual physician's training, experience and long-held community standards of practice.

Transfusion of Red Cells

Red cell transfusions are used to treat low red cell counts (anemia), which, if untreated, can cause weakness, lethargy, and in extreme cases, more severe symptoms such as shortness of breath or rapid heartbeat. Most physicians prescribe red cell transfusions before a patient develops serious symptoms, particularly when managing older patients or those with a history of heart or blood vessel disease. There are few scientific data that guide physicians as to the exact red cell count at which to prescribe a transfusion. The age of the patient, the level of his or her activity, the presence of other complicating medical conditions, and the likelihood and timeliness of the recovery of red cell production in the marrow each must be considered along with the red cell count.

All red cell transfusions need to be matched to the patient in the laboratory, and for patients with blood diseases the donated blood should always have the white cells removed by filtration. "Leukoreduced" or "leukodepleted" are the medical terms for white cell removal. Leukoreduction reduces the risks of fever and chills after transfusion, reduces the risk of not responding to platelet transfusions, and reduces the risk of transmission of some viral infections (e.g., cytomegalovirus, HTLV-1). Some centers use irradiation of all cell transfusions to patients receiving intensive chemotherapy or who are

considered to have impaired immune systems to prevent a rare but potentially life-threatening complication of transfusion called graft versus host disease. Patients undergoing blood or marrow stem cell transplants generally should receive irradiated blood components during the transplant period.

Transfusion of Platelets

Platelet transfusions are given to prevent or to treat bleeding due to severely low platelet counts (thrombocytopenia). There is controversy as to whether prophylactic platelet transfusions are necessary or beneficial, although it seems that maintaining a platelet count of greater than 5,000, and sometimes higher, reduces the risk of minor bleeding (e.g., nose bleeds, bruises in the skin called ecchymoses, pinpoint bleeding in the skin called petechiae). The platelet count at which most hematologists and oncologists believe prophylactic transfusion (in the absence of bleeding) is indicated has decreased from about 20,000 to 10,000 at most cancer centers, but there is great individual variation from physician to physician within this range, and from patient to patient. Uncommonly, patients bleed when their platelet counts go below 30,000, and most patients can tolerate stable platelet counts within a range of 5,000 to 10,000 without bleeding. The need for surgery or other invasive procedures often requires transfusion to maintain a much higher platelet count during surgery and for a period of healing thereafter.

Platelets can be given as pools made from several units of whole blood from different donors or single donor units obtained by hemapheresis. There is disagreement among physicians as to which approach is most appropriate; neither approach has been shown to be definitively superior or inferior. Donated platelets should ideally be ABO-identical with the patient's platelets, but there is controversy as to how important this is.

Donated platelet units should have the white cells removed by filtration prior to transfusion and, if appropriate, should be irradiated as well.

Transfusion of Granulocytes

A patient who has few or no circulating white cells may develop an infection that does not respond to antibiotics. In some such instances, use of a special technique (hemapheresis) to collect donor granulocytes may permit their transfusion and provide some benefit until the patient's own white cell counts recover. As with red cells and platelets, these transfusions should be irradiated prior to transfusion, but should not be treated with leukoreduction filters, as this would defeat the purpose of transfusing white cells. The white cells are infused through a standard blood filter that does not filter out white cells, but will filter out any particles or clotted blood elements. As mentioned, there is uncertainty over whether current methods of granulocyte collection produce an effective transfusion, which is why some protocols now include G-CSF stimulation of the granulocyte donor.

Transfusion of Plasma and Cryoprecipitate

Fresh frozen plasma (FFP) and cryoprecipitate, often called "cryo" for short, are transfused to patients who have abnormal or low levels of blood clotting proteins, such as in hemophilia. Clotting protein abnormalities in the plasma may develop in patients with poor clotting factor production due to liver disease or increased use due to infection. Fortunately, these conditions are uncommon in patients with hematologic malignancies, with the exception of promyelocytic leukemia. In this type of leukemia, abnormal clotting can occur and it may be necessary to transfuse these liquid fractions of donor blood to prevent or treat bleeding.

Use of Intravenous Gamma Globulin

Gamma globulin prepared from a pool of donor plasma is sometimes given to patients with hematologic diseases to supplement low levels, such as in patients undergoing stem cell transplants. Very low gamma globulins are a frequent feature of chronic lymphocytic leukemia. Severely low levels of gamma globulin can lead to an increased risk of some types of bacterial infections. Gamma globulin may also be of use in reducing the risk of cytomegalovirus disease and other immune complications of the disease or its treatment. Because gamma globulin is specially treated by techniques that cannot be used for cell transfusions, it does not carry the risk of transmission of viruses such as hepatitis C or HIV. Most side effects are very modest and can include mild headache, rash or hives.

Transfusion of Albumin

Rarely, transfusion of the most common human blood protein, albumin, is needed in patients who have severe liver malfunction. Albumin does not carry a risk of transmission of viruses such as hepatitis C or HIV. Side effects are uncommon with albumin transfusions.

Complications of Blood Transfusions

Most transfusions are not associated with any form of reactions. However, reactions can occur with any blood component. The reaction may occur at the time of the transfusion, such as abrupt high fever (called a febrile reaction) or the destruction of the transfused red cells (called a hemolytic reaction). Other deleterious effects, such as the transmission of viruses, are not apparent until weeks or months later, after the incubation period and the onset of the disease.

The symptoms of most of the reactions that occur during or soon after transfusion are similar. These include the development of a fever, chills, nausea, pain at the site of the transfusion (arm vein) or in the back, shortness of breath, a drop in blood pressure, passing dark or red urine, or a skin rash. Any patient noticing any change in his or her condition during a transfusion, however slight it may seem, should alert the nursing staff promptly. Serious complications can be prevented by early recognition of a reaction, stopping the transfusion and limiting the amount of blood given.

The initial management of all transfusion reactions is the same because the symptoms of different types of reactions may overlap. The transfusion is stopped and the unit is returned to the blood bank for examination to check for factors that might have caused the transfusion reaction. At the same time, the intravenous line is retained by infusing a glucose solution in case intravenous fluids or drugs are needed for treatment, and a physician is called. Blood samples may need to be drawn and treatment started right away. Many of these reactions, but not all, can be prevented or minimized by removing white cells from the component either at the bedside or in the blood center at the time of collection. Patients with hematologic diseases usually receive blood components units that are leukoreduced.

Reactions That Damage or Destroy Red Cells

Damage or destruction of the transfused red cells is rare. However, if this does occur, it represents the most severe and important acute reaction associated with blood components. Such a reaction, called a hemolytic transfusion reaction, can lead to a drop in blood pressure, bleeding or kidney damage which may be life-threatening. Because of this, all reactions are considered serious until a hemolytic reaction has been ruled out. Treatment of a hemolytic reaction includes taking measures to maintain the blood pressure and prevent kidney damage and bleeding.

Reactions That Cause Fever

Reactions that cause fever, referred to as febrile reactions, are the most common. These account for more than 90 percent of all transfusion complications. Fever is sometimes accompanied by chills, and on some occasions, shortness of breath. These reactions are frightening and uncomfortable for the patient but are usually not serious. However, they must be distinguished from the more serious hemolytic transfusion reaction mentioned above. While the reaction is being investigated, the transfusion is delayed. Treatment may be given to reduce the elevated temperature. Medicines can be given before the transfusion to prevent such a reaction. A fever reaction is most commonly caused by antibodies to the small number of white cells mixed with the red cells. The use of red cells from which white cells are removed, either at the bedside or at the time of collection, is a very effective means of preventing the high fever and chills. Unfortunately, during platelet transfusions, reactions causing high fever and chills are more frequent because the cause of these reactions is more complex. Filtering out white cells at the bedside is not as useful in preventing these effects. Washing of platelets as soon as they are prepared may be necessary in some situations if platelet transfusions are required repeatedly in susceptible patients.

Reactions That Cause Hives

Hives, which usually itch, are the second most common side effect of transfusion. The medical term for hives is urticaria. The skin changes are presumably due to soluble substances in the plasma of the donor that cause an allergic reaction in the patient. These reactions are themselves not dangerous but they do cause discomfort and anxiety to the patient. They can be treated with an antihistamine. For subsequent transfusions to susceptible individuals, the antihistamines can be given beforehand to prevent a reaction. This is the only reaction that does not necessarily require discarding the unit. If hives are present without any other symptoms, the transfusion can be restarted slowly once the hives have resolved.

The Patient Makes Antibodies to the Donor's Blood

Some patients may produce antibodies against certain antigens in transfused blood. Although blood is typed for the most important antigens on the red cell, ABO and Rh, there are many other antigens on red cells, white cells, platelets, or occasionally in the plasma that can cause a patient to make antibodies against the donor blood. The medical term for this phenomenon is "alloimmunization." This effect does not necessarily cause immediate symptoms but is important if subsequent transfusions are needed. With red cell transfusions the situation can be managed by selecting donors for future transfusions with red cells that do not carry the antigens to which the patient has made an antibody. The compatible blood can usually be obtained by testing the units in the blood bank. However, occasionally a blood unit may need to be shipped in from another blood center. This type of exchange between blood centers is a common practice and provides a national pool of blood when necessary.

With platelet transfusions the antibodies are formed against white cells. However, these antibodies may also destroy the transfused platelets.

Specifically matched platelets will need to be collected if this occurs. Most blood centers have a pool of volunteer blood donors who have been HLA typed and are willing to donate by hemapheresis. The platelets will then all come from a few specifically matched donors who each provide a large dose of platelets. A donor's propensity to make antibodies to white cells can be reduced – but not completely prevented – by the transfusion of red cells and platelets only, with the white cells removed.

Transmission of Viral Infections

Blood is a biological substance and may never be entirely risk-free. However, the chance of getting a viral disease following blood transfusion has decreased markedly in the last 20 years. However, the risk has not been eliminated because indirect tests, using detection of antibodies to the viruses, cannot detect infections that occur between the time of exposure to the virus and the appearance of the antibody. This period is referred to as the "window period," and if a donation is made during this time there remains a very small residual risk of viral transmission. This is one reason why screening out donors at risk of a transmissible virus infection by careful interview remains an important aspect of blood safety procedures. Since 1999 the risks of HIV and hepatitis C are considerably reduced because more sensitive nucleic acid testing for the virus has been introduced. The number of blood units found to be positive for HIV or hepatitis C virus was decreased to one per two million. Since units that test positive for virus are discarded, the risk in the year 2003 appears to be dramatically reduced for both HIV and hepatitis C virus. Hepatitis B virus nucleic acid testing may eventually be introduced.

Recent estimates of the frequency of disease transmission by a single unit of blood are shown in Table 1.

Table 1. Risk Estimates for Blood Transfusions in the U.S.

	Risk per Unit
Human Immunodeficiency Virus Using P24 Testing	1:2 million
Human Lymphocytotrophic Virus	1:3 million
Hepatitis C Virus	1:2 million
Hepatitis B Virus	1:200,000

Source: American Red Cross, BloodSafety.org

Transmission of Cytomegalovirus (CMV)

Cytomegalovirus (CMV) is a common virus, and about 50 percent of individuals in the U.S. have been infected with it by the time they are 50 years old, most without developing symptoms. However, in premature babies and in patients undergoing blood or marrow stem cell transplantation, CMV infection can cause serious problems, such as pneumonia. CMV infection may be due to reactivation of the virus from a previous exposure or from prior blood transfusion. Patients with leukemia and those undergoing blood or marrow stem cell transplantation, who themselves have no antibodies to CMV, should receive blood components that are negative for CMV antibodies. Since the virus resides in white cells, it can be transmitted by blood components that contain white cells. Removal of white cells from blood components is another approach to preventing CMV. This approach appears to be as efficient as providing components from CMV antibody-negative donors.

Transmission of Bacterial Infection

Infection with bacteria due to a blood transfusion is an extremely rare complication with red cell transfusions, in the order of one per million transfusions. Blood is collected and processed in a sterile system. However, bacteria are very occasionally present in the donor's blood at the time of donation or the blood is contaminated at the time of collection. Red cells that are stored at refrigerator temperatures do not usually provide the right conditions for organisms to grow, so that infection from red cell transfusions is the least common complication. However, platelets that are kept at room temperature can allow bacteria to grow in a contaminated unit. Therefore, infection following platelet transfusions is more common than with red cell transfusions. Culturing all hemapheresis platelets for bacteria is now done by all blood centers in the U.S., and methods of doing the same for platelets made from whole blood are being developed.

Graft Versus Host Disease (GVHD)

Donor white cells (lymphocytes) can attack the recipient's skin, liver, bowel and marrow after blood or marrow stem cell transplantation. The result of this attack is called graft versus host disease (GVHD). Donor lymphocytes from a blood transfusion have the potential to produce a similar reaction in the recipient. Although this is very uncommon, it may happen in patients who have decreased immune system function, referred to as "immunosuppressed" or "immunocompromised." Immunosuppression can result from a disease or intense or prolonged chemotherapy or radiation therapy. Most centers treat all blood components for transfusion to patients who are severely immunosuppressed with irradiation. Fortunately, this very severe complication is rare and almost never occurs after transfusion of irradiated blood. Recipients of stem cell transplants may develop graft versus host disease but these complications are usually easier to manage than graft versus host disease resulting from transfusions.

Effect on a Patient's Immune System

There is a controversial theory that transfusions can cause decreases in immune function. The medical term for this effect is "immunomodulation." It is not clear what the implications of this effect, if any, are for patients with leukemia, lymphoma, myeloma or related diseases. In other clinical settings (surgery) filtering out white cells from transfusion components appears to prevent deleterious immune effects of transfusion to a large degree.

Blood Donation

The need for blood transfusions for patients with leukemia, lymphoma and many other diseases never takes a holiday. Every day thousands of blood components are transfused to patients. Blood cannot be made artificially; thus, patients' lives literally depend on volunteers who give blood on a regular basis. As the population gets older and more sophisticated medical practices are developed, the need for blood component therapy will grow as well. In many areas of the country, blood centers have had difficulty keeping up with the need, and as a result there have been frequent shortages.

About 60 percent of the U.S. population is eligible to donate blood. People in good health, at least 17 years old, and weighing at least 110 pounds may donate blood every two months. Family members and friends often ask what they can do to help support their loved one during their illness. One relatively easy and simple thing eligible people can do is to donate blood, and encourage other friends and families to donate, too. Blood centers often are able to send a card to the patient after a donation is made, to acknowledge the donor's gift in the patient's name. While there should be no pressure to donate, this is one altruistic and valuable contribution to the care of the patient and costs the donor no money. The gift of blood donation supports all patients and families dealing with leukemia, lymphoma, myeloma or other diseases for which transfusions may be an essential part of treatment and ensures that blood will be available when it is needed.

Resources

Understanding Blood Counts Fact Sheet. The Leukemia & Lymphoma Society, 2003.

Blood and Marrow Stem Cell Transplantation. The Leukemia & Lymphoma Society, 2005.

Understanding Drug Therapy and Managing Side Effects. The Leukemia & Lymphoma Society, 2004.

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