Blood Donation

There is always a need for blood donors. Modern medical care, including surgery and medical treatment for many diseases, is not possible without the use of blood products. A shortage of blood products means that someone may not get prompt, adequate care.

Whole blood is collected from healthy donors who are required to meet strict criteria concerning:

- Medical history
- Physical health
- Possible contact with transfusion-transmissible infectious diseases, including a history of:
    - Sexual behavior
    - Drug use
    - Travel to areas of endemic disease (e.g., malaria)

A photo identification is required for all donors. The potential donor must:

- Be in good health and feeling well on the day of donation.
- Be on no prescribed medication that would cause the donor a problem when donating or that would affect the recipient
- Have a hemoglobin (red blood cell) level, which meets the established U.S. Food and Drug Administration (FDA) standard.
- Wait 56 days before giving another donation of whole blood.

All donors are required to complete a health questionnaire and blood safety form during a confidential interview by a donor center health care worker each time they come in to donate blood. The purpose of this process is to determine whether a donation can be obtained safely.

Please note that AIDS and other infectious diseases CANNOT be transmitted to a blood donor. The equipment used to collect blood is sterile, used only once and then discarded. There is NO risk of contracting AIDS or any other infectious disease by donating blood.

Autologous Donations

An "autologous" donation occurs when a person donates his or her own blood for personal use. This means that, since the blood is not being used for anyone else, then units positive for infectious agents and units with irregular blood group antibodies are still acceptable for autologous donation.

However, because of the potential risk for a clerical error with mistransfusion of an autologous unit in the inventory, units positive for hepatitis B (HBsAg) and human immunodeficiency virus (HIV) are not allowed into the Blood Bank. If an autologous unit is collected but not used by the patient-donor, then it is destroyed.

There are three other ways, aside from the "predeposit" of blood as outlined above, to make use of the patient's own blood:

1. Hemodilution: the patient's blood is collected prior to surgery and replaced with a plasma expander. The theory is that any bleeding during surgery will lose fewer RBC's. Then the previously collected, higher hematocrit blood can be given back to the patient following surgery.

2. Cell Saver: this device is used to collect blood in the operative field during surgery, wash it, and return it with saline to the patient. This will work as long as the operative field is not contaminated with bacteria or with malignant cells.

3. Wound drainage: blood is collected from cavities (such as a joint space into which bleeding has occurred) and returned through a filter (which removes big items like thrombi and tissue fragments, but does not remove inflammatory chemical mediators or cytokines).

Directed Donations

A "directed" donation occurs when the potential recipient of blood or blood products designates certain persons to donate specifically for his or her use. In general, blood collected from directed donations is no safer than that of the general blood supply because of the stringent screening and testing of volunteer donors that ordinarily occurs.

Additional problems with directed donations include:

1. Confidentiality of the donor is difficult to maintain.

2. The donor may not want to answer the exclusionary questions of the blood safety form and health questionnaire properly.

3. This procedure is not cost-effective.

4. There are contraindications, such as an increased risk for transfusion-associated graft versus host disease (TAGVHD), alloimmunization of potential recipients of transplants, and increased risk for hemolytic disease of the newborn in mothers receiving blood from fathers.

There is a small but significant risk for TAGVHD in persons receiving blood from relatives, because of similar genetic makeup. TAGVHD is fatal, with no effective treatment. Thus, all units of blood collected by directed donation typically undergo gamma irradiation to destroy any white blood cells that could cause TAGVHD. This adds significantly to the cost of blood processing, and these units must be discarded if not used within 24 hours.

Patients who request directed donations from family and friends often do not realize the pressure such a request can place upon an individual who does not qualify to donate blood. That individual, if answering the questions in the interview properly, will be excluded from donating, which will result in family members asking questions about why the blood was not accepted. The alternative is answering the questions untruthfully and compromising the safety of the blood products collected.

Tests Performed

Laboratory tests must be completed before blood or blood products can be transfused:

- Determination of the blood type with a crossmatch.
- Screening for antibodies that may produce adverse effects if transfused.
- Screening for possible infectious agents that could be transmitted with transfusion.

The following tests are mandatory on all units of blood collected for transfusion:

- ABO group and Rh type
- Screening for blood-group antibodies
- Serologic tests for human retroviruses including:

    HIV-1

    HIV-2

    HTLV I

    HTLV II

- Serologic tests for viral hepatitis including:

    Hepatitis B

    Hepatitis C

- Serologic tests for additional infectious agents including:

    Syphilis (*Treponema pallidum*

    West Nile virus

    Chagas disease (*Trypanosoma cruzi*)

If, and only if, all of these markers are negative can blood be conveyed to the Blood Bank for storage until usage. A positive results for some of these tests may prevent further donation by that person. A person with such a test result will be notified by the donor center. Persons with a potential medical condition should see a physician and should not, under any circumstance, donate only to have blood tested. These measures are done to make the blood supply as safe as possible. The significant infectious diseases transmitted by transfusion and the risk of transmission (RT) in the U.S. are given below.

Transfusion Transmitted Diseases

Hepatitis B

Hepatitis B virus (HBV) is transmitted through parenteral and sexual exposure. The incubation time is a mean of 90 days with a range of 30 to 180 days.

Donor blood is routinely tested for HBsAg and HBcAb. There is no routine testing for hepatitis A, because it is rarely transmitted by blood products.

Recipients of blood products can also be infected with hepatitis delta, which is a defective RNA virus that needs a HBV superinfection to replicate.

Persons who have received a hepatitis B vaccination (recommended for all health care workers with patient contact) will have hepatitis B surface antibody present, but not HBsAg or HBcAb

Risk of transmission (RT) = 1 in 200,000 to 500,000

Hepatitis C

The route of transmission is parenteral, with sexual transmission lower than previously thought. The mean incubation time is 6 to 8 weeks.

Blood Bank testing for HCV started in 1990. At present, only testing for hepatitis C antibody is available.

Risk of transmission (RT) = 1 in 1,000,000 to 2,000,000

Human Immunodeficiency Virus (HIV)

In 1982 the first cases of AIDS obtained from blood or blood components were reported, but the etiology of the infections was not known at that time.

By 1983 changes occurred in the donor criteria to exclude those at high risk for transmission of HIV.

The first testing of blood products for HIV started in 1985 and is a test to detect the presence of antibody directed against HIV. Testing for HIV p24 antigen was mandated in 1996.

Risk of transmission = 1 in 1,000,000 to 2,000,000

Human T-lymphocytotrophic Virus (HTLV-I/II).

HTLV-1 is a retrovirus that is endemic in Japan and the Caribbean. Implicated as causing adult T-cell leukemia/lymphoma and a neurological disorder similar to multiple sclerosis.

Blood is routinely screened for antibodies to HTLV-I.

Risk of transmission = 1 in 2,000,000 t0 3,000,000 (but only 1-3% of seropositive individuals will develop disease).

Cytomegalovirus (CMV)

The prevalence of CMV antibody ranges from 50 to 80% of the population. Blood contaminated with CMV can cause problems in neonates or immunocompromised patients.

Potential problems in selected patient populations can be prevented by transfusing CMV negative blood or frozen, deglycerolized RBC's.

Donor blood is not routinely tested for CMV.

Malaria

Malaria is rarely transmitted by RBC products, although the number of transfusion associated cases of malaria is at an all-time high.

Donors travelling to high-risk malaria areas are excluded from donating blood for six months. In areas of high prevalence, an antibody test to detect *Plasmodium falciparum* and *Plasmodium vivax* can be employed.

Bacterial Contamination

Bacterial contamination of blood can occur during collection. Bacteria can grow during storage at room temperature and during refrigeration (psychrophilic organisms). Platelet products carry the greatest risk (1 in 3000 units may have bacteria), because they are stored at room temperature. Transfusing a contaminated unit may uncommonly result in severe sepsis (1 in 100,000), septic shock and death.

Others

Additional diseases which are rarely transmitted by blood products include:

1. Lyme disease

2. Dengue fever

3. Babesiosis

4. Creutzfeldt-Jakob disease

Potential donors may be screened by questionnaire regarding travel to endemic areas or contact with persons at risk. Antibody tests available for all but babesiosis and CJD are available, preferentially applied in regions of high prevalence.

Blood Compatibility Testing (Crossmatch)

A "type" includes a "front type" and a "back type". The "front type" determines which antigens ("flags") in the ABO blood group system are on the patient's red blood cells. The "back type" identifies the isohemagglutinin (naturally occurring antibody) in the patient's serum and should correspond to the antigens found on the red blood cells. In addition, RBC's are Rh typed and identified as "D" positive or negative.

Requesting Blood Products

"Type and Screen" - This is requested when it is unlikely that blood will be needed emergently. There are no donor units specifically matched and reserved for the potential recipient patient. However, the patient's blood type is identified, and a screen will have identified potential antibodies that could complicate obtaining blood. A crossmatch to find compatible units can be done more easily following a "type and screen."

"Type and Cross" - This is requested when it is likely that blood will be needed. Compatibility testing between patient and donor units is performed and at least 2 units are crossmatched for the patient and reserved specifically for that patient. These units cannot be used for anyone else. If they are not used, then they can go back into the inventory for use by others.

The "screen" looks for unexpected red cell alloantibodies which may form following pregnancy or prior transfusions. If the screen is positive, the antibody is identified. The physician is also notified. Antibody identification can be complicated and take more than a day to complete.

- **A full crossmatch procedure takes about 45 minutes to complete and cannot be shortened.**
- **Units are refrigerated until used.**
- **A unit of blood must be properly labeled and the label MUST be checked before use.**

Every unit crossmatched is removed from the general inventory and reserved for the patient for 72 hours. Units that are crossmatched unnecessarily will deplete Blood Bank inventories and can result in blood shortages. Blood shortages can result in cancellation of elective surgical procedures.

Blood will ordinarily not be released for transfusion until compatibility testing is completed. However, under emergency conditions, blood products may be released without a crossmatch if the patient is in danger of dying if transfusion is delayed. In such cases, if the patient's blood type is not known, then group O Rh negative (O neg) blood can be released without compatibility testing. In cases in which the patient's blood type is reliably known, then type-specific blood or RBC's of the same ABO and Rh group may be released.

Blood Preservation and Storage

Blood can be stored as whole blood (with all of the plasma present) or, much more commonly, as packed red blood cells (PRBC's) in which about 70% of the plasma has been removed. This is done by light centrifugation. The platelet rich plasma can then be expressed off, leaving packed red blood cells (PRBC's.

Both whole blood and PRBC's can be stored for up to 42 days at 1 - 6 degrees C.

The plasma can be centrifuged heavily a second time to separate the platelet rich plasma. The supernatant plasma can be expressed into a third bag and stored as fresh frozen plasma (FFP). The remaining platelet rich plasma is utilized as a platelet pack, as shown below:

Thus, a single donation of whole blood has supplied three separate components (packed red blood cells, platelets, fresh frozen plasma) that can potentially benefit three different patients.

After the expiration date, rare or valuable blood units can be "rejuvenated" with a biochemical solution that restores much of the original biochemical environment of the RBC's. The "rejuvenated" units are "washed" with isotonic saline in an automated device and then can be transfused as a saline-red blood cell suspension within 2 to 4 hours, or these units can be stored glycerolized and frozen for up to 10 years.

Cryopreservation of RBC's is done to store special, rare RBC's for up to 10 years. The RBC's are first incubated in a 40% glycerol solution which acts as an "antifreeze" within the cells. The units are then placed in special sterile containers in a deep freezer at less than -60 degrees C.

Cryopreserved units are thawed and washed free of glycerol prior to use as saline suspended RBC's. These units must be used in 2 - 4 hours to prevent possible bacterial contamination. The washed units are depleted of plasma and leukocytes.

Cryopreserved blood can help to maintain stores of Rh negative blood, to provide units for persons with antibodies to high-incidence antigens or persons difficult to cross-match because of multiple alloantibodies and to provide plasma-free blood to persons with IgA deficiency.

Thus, the types of RBC products available are:

- Packed red blood cells (PRBC's)
- Leukocyte depleted RBC's: cryopreserved blood that is thawed and degylcerolized is depleted of leukocytes, but much better depletion can be obtained by filtering the blood through leukocyte-specific filters.
- Frozen, deglycerolized RBC's

Transfusion Reactions

Hemolytic Reactions

Hemolytic reactions occur when the recipient's serum contains antibodies directed against the corresponding antigen found on donor red blood cells. This can be an ABO incompatibility or an incompatibility related to a different blood group antigen.

Disseminated intravascular coagulation (DIC), renal failure, and death are not uncommon following this type of reaction.

The most common cause for a major hemolytic transfusion reaction is a clerical error, such as a mislabeled specimen sent to the blood bank, or not properly identifying the patient to whom you are giving the blood. DO NOT ASSUME IT IS SOMEONE ELSE'S RESPONSIBILITY TO CHECK!

Allergic Reactions

Allergic reactions to plasma proteins can range from complaints of hives and itching to anaphylaxis. Such reactions may occur in up to 1 in 200 transfusions of RBCs and 1 in 30 transfusions of platelets.

Febrile Reactions

White blood cell reactions (febrile reactions) are caused by patient antibodies directed against antigens present on transfused lymphocytes or granulocytes. The risk for febrile reaction is 1 in 1,000 to 10,000.

Symptoms usually consist of chills and a temperature rise > 1 degree C.

Transfusion related acute lung injury (TRALI)

TRALI is now the leading cause for transfusion-related mortality. It is caused most often when donor plasma contains HLA or leukocyte (usually granulocyte) specific antibodies. Recipient leukocytes may be 'primed' by underlying illness to become more adherent to pulmonary alveolar epithelium. Introduction of the donor antibodies into the recipient causes granulocyte enzymes to be released, increasing capillary permeability and resulting in sudden respiratory distress from pulmonary edema, typically within 6 hours of transfusion. Leukopenia may transiently occur. Most cases improve within 2 days.

TRALI most often occurs with administration of blood products with plasma, such as FFP. Use of plasma from men reduces the incidence of TRALI, since women who have been pregnant are more likely to have higher titer HLA antibodies.

Circulatory Overload

Circulatory overload can occur with administration of blood or any intravenous fluid, particularly in patients with diminished cardiac function.

Massive Transfusion and Massive Blood Loss

Massive blood loss, which s defined as the loss of one blood volume within a 24 hour period, a 50% loss in less than 3 hours for acute scenarios, or a rate of loss of 150 ml/min.

Massive transfusion is the lifesaving treatment of hemorrhagic shock that requires the transfusion of one blood volume. Major complications that may arise in patients who require massive transfusion include hypothermia, coagulopathy, and/or citrate toxicity with electrolyte abnormalities and metabolic derangements, such as acidosis and alkalosis.

Alloimmunization

RBC's

RBC transfusions can expose the patient to RBC antigens not recognized as self. If an antibody is produced, future transfusions can be delayed because extended donor blood typing will be required to identify compatible units.

O negative blood released uncrossmatched in emergencies could result in a hemolytic transfusion reaction if the patient has an alloantibody produced after a previous transfusion.

Hemolytic Disease of the Newborn

Alloantibody production in a female can result in hemolytic disease of the newborn. Previous pregnancies expose the mother to novel (paternally derived) antigens. The most common alloimmunization associated with pregnancy is the exposure of maternal Rh D negative blood to fetal Rh D positive blood. This results in the production of maternal IgG against the "D" antigen that can cross the placenta and attack fetal red blood cells, resulting in hemolytic disease of the newborn, also called erythroblastosis fetalis.

Erythroblastosis fetalis can be prevented by the use of Rho(D) immune globulin, commonly known as RhoGAM. RhoGAM consists of IgG anti-D antibodies that will help neutralize the antigen and prevent the mother's immune system from sensitization to the antigen, and preventing the immune response that generates the alloantibodies. The use of RhoGAM has greatly reduced the incidence of Rh anti-D erythroblastosis fetalis, and so other blood group antigens, such as Kell, may be implicated.

Platelets

Platelets contain HLA and A & B antigens. Prior exposure to non-self HLA antigens (from WBC contamination of red cell products) can result in antibodies that will render future platelet transfusions useless.

Obtaining Compatible Blood Products

If an alloantibody is detected, then RBC units may be crossmatched randomly, assuming that the alloantibody is against a "low incidence" antigen which most units will lack. Chances are, enough compatible units will be identified.

If an alloantibody is directed at a "high incidence" antigen, then there will be few, if any, units available that match. In that case, "rare" blood units lacking the antigen may be requested from a facility that stores such blood. Cryopreservation of RBCs is done to store special, rare RBCs for up to 10 years in a glycerol solution. The thawed units are washed of the glycerol, and by doing so are also depleted of plasma and leukocytes.

For platelets, HLA (MHC) typing may be necessary to identify compatible donors with the same HLA type. HLA unmatched platelets (random donor platelets) are likely to be destroyed readily.

The process of identifying alloantibodies and finding compatible blood products is time consuming.

Graft Versus Host Disease (GVHD)

GVHD is a situation where transfused lymphocytes engraft and multiply in immunocompromised patients (e.g., bone marrow transplant patients). The newly engrafted lymphocytes attack the host. This is the opposite of a host rejecting a transplanted organ (e.g., a heart).

Transfusion-associated graft versus host disease (TAGVHD) is a different disease from GVHD in allogeneic bone marrow transplant recipients. TAGVHD is uniformly fatal and untreatable. It occurs when the blood products contain T-lymphocytes and attack many host tissues. It occurs when the recipient is immunocompromised

TAGHVD is prevented by gamma-irradiating the blood products to be transfused.

What is Apheresis?

The process of apheresis involves removal of whole blood from a patient or donor. Within an instrument that is essentially designed as a centrifuge, the components of whole blood are separated. One of the separated portions is then withdrawn and the remaining components are retransfused into the patient or donor.

The components which are separated and withdrawn include:

- Plasma (plasmapheresis)
- Platelets (plateletpheresis)
- Leukocytes (leukapheresis)

Therapeutic Apheresis

The purpose of therapeutic apheresis is to remove a component of the blood, which contributes to a disease state. Examples include:

- Plasmapheresis: within the plasma are contained antibodies and antigen-antibody complexes that may contribute to the deleterious effects of autoimmune diseases. Removal of the plasma (and replacement with saline solution) will help to reduce circulating antibodies and immune complexes. In rare circumstances, excess blood proteins are present that may cause circulatory problems. Examples of these diseases include:

  Waldenstrom's macroglobulinemia

  Myasthenia gravis

  Guillain-Barré syndrome

  Hyperviscosity Syndromes

  Paraproteinemia

  Cryoglobulinemia

  Goodpasture's syndrome

- Plateletpheresis: rarely, in myeloproliferative disorders, the platelet count can be very high (thrombocytosis). Removal of platelets can help to avoid complications of thrombosis and bleeding.

- Leukapheresis: in some cases of leukemia with very high white blood cell counts, removal of the excess leukocytes may help to prevent complications of thrombosis.

- Stem Cell Harvesting: the small number of circulating bone marrow stem cells can be harvested to use in transplantation procedures.

Donation by Apheresis

The process of apheresis has become essential in providing blood components for therapy. A volunteer donor will undergo apheresis to supply specific components. The process takes a couple of hours. Examples include:

Plateletpheresis: this is the most common means for supplying HLA matched platelets to patients who have become HLA sensitized and require platelets from a single donor whose HLA type matches theirs.

Plasmapheresis: the plasma can be removed to supply blood components such as clotting factors. Donors can give plasma via this mechanism more often than they can donate whole blood.

Leukapheresis: the leukocytes (specifically the granulocytes) can be harvested from a donor to supply granulocytes to help fight infection in patients such as neonates.