Utilization of Blood and Its Products*

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The development of a system of plastic bags connected by integral tubing for the collection, processing and storage of blood has made it possible for selective transfusion of appropriate blood components. It is now possible to select the blood component that will correct a patient's physiologic deficiency. This has resulted in better patient care and in better utilization of blood since a single unit of blood can be used to supply erythrocytes for an anemic patient, platelets for a patient with thrombocytopenia and factor VIII concentrate for a patient with hemophilia.

In order to utilize blood and its components optimally, there must be a close working arrangement between the blood bank personnel and the clinical staff. At the time when blood is obtained from a donor, a decision should be made concerning how the blood will be used. Several of the components can be prepared only from fresh blood. The equipment, supplies and personnel time should be used to produce the maximum benefit to the recipients of the blood. Although each unit of blood could be separated into several useful components, it is a wasteful procedure if the components are not used. Each institution must determine its need for blood and blood components. Those responsible for the operation of the blood bank should not make unilateral decisions about the preparation of blood components and the clinical staff should not make unilateral decisions about the use of blood components.

Packed Red Blood Cells. When blood is collected in the proper closed bag system, it is possible to remove much of the plasma after sedimentation or centrifugation without opening the container. The resulting packed red blood cells remain viable for transfusion purposes for 21 days when stored under standard conditions. The obvious advantage of transfusing packed red blood cells is that the circulating erythrocyte mass of the recipient can be increased without increasing the circulating plasma volume. This minimizes the possibility of circulatory overload. It has been estimated that up to 80 percent of the transfusions should be in the form of packed red blood cells (2).

Along with the plasma, most of the sodium added in the anticoagulant solution is removed. This can be an important factor when transfusions are necessary in patients requiring limited sodium intake. In addition to the excessive amounts of electrolytes and citric acid, the plasma contains antibodies. One of the dangers in the universal donor concept is that the plasma of group O individuals contains antibodies against group A and group B cells. These antibodies are removed along with the plasma. Although type specific compatible erythrocytes are the treatment of choice, in an emergency situation when such blood is not available, group O packed red blood cells are an acceptable form of therapy.

Factor VIII Concentrates. The treatment of hemophilia with plasma rather than whole blood was an early form of component therapy. It was found that plasma contains the material lacking in hemophilia and except for the occasional patient with anemia, whole blood is seldom needed for the treatment of hemophilia. Although the antihemophilic factor in plasma is relatively labile, it can be maintained in plasma stored below $-18°C$. Until relatively recently, plasma removed from whole blood within a few hours of collection and then promptly frozen was the only available source of factor VIII for human use. Because of the relatively small amount of antihemophilic activity in plasma, large amounts of fluid had to be infused

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to significantly increase the circulating level in the patient. In addition, the infused activity was retained in the circulation for only a short period of time (4). Thus, therapy was restricted to the amount of fluid that could be infused without causing overload.

In 1965, Pool and her associates (5) reported that when frozen plasma was thawed slowly, a poorly soluble, gelatinous precipitate was formed. This material, called cryoprecipitate, was found to contain a considerable amount of the antihemophilic activity of plasma. Thus, it became possible to concentrate and collect factor VIII of plasma in a closed bag system. The resulting material contains, on the average, about half of the antihemophilic activity of the original plasma and in a relatively small volume.

Although the treated plasma can be returned to the cellular component and used as whole blood, most have found it better to utilize the plasma for other purposes. The residual plasma can be used for all conditions where plasma is indicated other than for the treatment of hemophilia.

Platelet Concentrates. Fresh whole blood contains viable platelets which will function when transfused. When platelets are needed to control bleeding in a patient with thrombocytopenia, however, a large amount of blood must be infused to increase the platelet level in the circulation. Platelets can be separated from whole blood and transfused in a relatively small volume.

Platelets have a specific gravity of 1.040 while the specific gravity of erythrocytes is about 1.095 (3). Since platelets are lighter than erythrocytes, the red blood cells can be sedimented by low speed centrifugation while the platelets remain suspended in plasma. In this way platelets can be separated from whole blood in a closed bag system. Platelets, however, have a very short shelf life and to be effective must be infused promptly after collection. Although platelets lose viability rapidly, approximately half of the recovered platelets are still effective after 72 hours of storage. Most workers, though, feel that platelets should be used within the first 48 hours after collection. Although there is some evidence that room temperature storage has some advantages, it is felt that best results are obtained when platelets are stored at 4°C. Additional studies of storage are necessary to determine optimal conditions (1).

Platelets can be given along with the plasma as platelet rich plasma. It is usually necessary, however, to give the platelets recovered from six units of blood to achieve the desired effects and it is normally not desirable to give this amount of fluid. The usual practice is to concentrate the platelets by centrifugation and remove all but approximately 30 ml of plasma. Following centrifugation, it may be difficult to resuspend the platelets. Gentle agitation after storage for about one hour has been found to result in a satisfactory product. It is generally recommended that platelets be infused through a filter to remove any large aggregates.

Plasmapheresis. One of the limitations of obtaining blood is that approximately six-to-eight weeks are required for the regeneration of erythrocytes. For this reason, the interval between individual donations of blood should be at least eight weeks. The regeneration of the fluid volume and plasma proteins is more rapid. With a series of bags connected by integral tubing, it is possible to withdraw blood from a donor, separate the erythrocytes from the platelet rich plasma and return the erythrocytes to the donor. This process, called plasmapheresis, can be repeated at frequent intervals without danger to the donor.

This technique has several advantages when the needs for platelets and plasma are great. A relatively small number of donors can supply considerable amounts of platelets and plasma. There is increasing evidence that when platelets are given over a prolonged period, antibodies to platelets develop in the multitransfused patient. These antibodies appear to be directed against the histocompatibility antigens of the HL-A system. Those institutions which use platelet transfusions on a long-term basis have found that best platelet survival occurs when there is an HL-A compatibility between donor and recipient. It is generally felt that if a series of platelet transfusions are required, it is best to obtain platelets by plasmapheresis from a few histocompatible donors rather than utilizing platelets from a number of random blood donors (7).

Frozen Red Blood Cells. With currently available techniques, erythrocytes retain sufficient viability for transfusion purposes for only 21 days. For this reason blood supplies must be continuous and the blood bank must be able to predict its needs so that sufficient blood will be available and yet there will not be wastage due to excessive

amounts of erythrocytes lost by out-date. An obvious solution would be to develop a method of preservation of blood for longer periods.

A number of chemical additives have been used in an attempt to prolong the viability of erythrocytes. The most promising has been adenine (6). With the addition of adenine at the time of collection, there is evidence that erythrocytes remain viable up to 40 days under the usual storage conditions. At the present time, however, there is not sufficient evidence to be certain of the safety of this material for human use.

Other workers have demonstrated that erythrocytes suspended in cryoprotective solutions retain viability almost indefinitely when stored at low temperatures. Before the erythrocytes can be infused, the cryoprotective materials must be removed. The supplies and equipment necessary for preparation, storage and washing make this technique rather expensive. Although the techniques are practical, the cost for a unit of such blood is almost prohibitive for routine use. If methods can be developed to decrease the cost, there are many advantages to such a technique.

Leukocyte-Poor Blood. There are many known antigens associated with erythrocytes, but most of these are only occasionally of clinical significance. For practical purposes, it is only necessary to routinely test for ABO and Rh antigens. In a similar way there are a number of antigens associated with leukocytes, but these are usually of little clinical significance. In multitransfused patients, however, the leukocytes may cause reactions. To prevent these reactions it may be necessary to give leukocyte-poor blood. Recently it has been recognized that leukocyte antigens may have an adverse effect on organ transplantation. It has been suggested that patients with chronic renal disease who may be candidates for renal transplantation should be given only leukocyte-poor blood.

The specific gravity of granulocytes is 1.087–1.092 and the specific gravity of lymphocytes is 1.070 (3). Thus differential centrifugation to prepare leukocyte-poor erythrocytes is rather difficult. There are techniques by which most of the leukocytes can be separated from erythrocytes but these techniques are tedious and time consuming. In order to remove the leukocytes and their antigens it is necessary that fresh blood be used. In those institutions that have a frozen blood program, it has been found that this preparation is an excellent source of leukocyte-poor erythrocytes.

Summary. At the present time there are a number of blood components that are more suitable for transfusion purposes than is whole blood. In order to make maximum use of blood, it is necessary that there be close cooperation between the blood bank personnel and those responsible for patient care.

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