Presently Useful Plasma Volume Expanders

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A thorough knowledge of plasma volume expanders and their relative usefulness in relation to whole blood is necessary for those who must treat critically injured patients. The result of misunderstanding the role of plasma expanders has always been disastrous both for the individual patient and for the community. For example, General Kendrick has charged that the treatment of thousands of American soldiers was inadequate during the early years of World War II because the Surgeon General thought that plasma could entirely substitute for whole blood in treating combat casualties. At that time, the toxic theory of shock had influenced many medical leaders to place more faith in plasma than was ever justified.

Partly as a result of medical reaction to overemphasis on plasma and partly as a result of the fear of homologous serum jaundice, plasma was used less after World War II except in the treatment of specific plasma-losing illnesses. However, in the nineteen-fifties a method for rendering plasma less infectious was developed, and the fractionation products of plasma became more acceptable for the treatment as well of diseases such as cirrhosis and nephrosis. As a result, human plasma is more in demand than ever before, for infusion and for fractionation.

At present the role of plasma volume expanders is limited to the treatment of hemorrhagic shock when whole blood is not available, the replacement of plasma lost as a result of tissue damage and to restoring plasma oncotic pressure when plasma proteins are markedly decreased. In the latter instance, concentrated solutions are necessary to achieve elevation of plasma oncotic pressure.

In evaluating plasma expanders it is necessary to know first the advantages, the availability, the relative expense, and the special limitations of each product. Table 1 lists the various products presently available commercially but does not list products which are available on a research basis or solely from hospital blood banks.

In the past, some of the products available on a research basis have been widely used clinically, but the present food and drug laws have greatly restricted the availability of nonofficial preparations. In addition, the use of nonofficial preparations may invite legal difficulties should an individual patient prove litigious. The products in table 1 are official in the United States only.

The prices listed (as of January 1, 1966) are corrected to give the cost of each product in terms of the replacement of 250 ml. of normal plasma volume. This correction is essential because salt-poor serum albumin is customarily packaged as 100 ml. of 25 per cent solution per "unit," and this is actually the equivalent of two 250 ml. units of normal plasma, in protein content.

As can be seen from the table, the use of a plasma product can be quite costly when a crystalloid or synthetic solution will have the same effect. In view of the limited availability and relative high cost of plasma products, many hospitals may consider a knowledge of table 1 an essential part of the education of those physicians who will be caring for indigent patients.

Single Donor Plasma

Plasma aspirated from a single unit of stored ACD blood is an excellent agent for expanding plasma volume. In emergencies, such plasma is readily available in any moderate-sized blood bank and its usefulness is also readily comprehended by technician and clinician alike. Unfortunately, the use of such plasma is frequently wasteful; entering the blood container for aspiration of plasma exposes the blood to contamination and thus ends its usefulness as

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a sterile transfusion material. In addition, the transfusion of aspirated plasma exposes the patient to the risk of both transfusion reaction and homologous serum jaundice. Moreover, stored plasma is deficient in clotting factors owing to storage and will not be therapeutically effective if a bleeding tendency exists. It is clear, therefore, that the use of such a simply prepared product is best limited to emergencies and that careful planning should make available a product which either offers something additional in the way of advantage or something less in the way of risk.

Single donor plasma can be administered with fewer precautions than whole blood since there are no donor red cells to be hemolyzed. Nevertheless, it is inadvisable to ignore the ABO groups of the donor entirely, since a high titered incompatible isoagglutinin present in the plasma can destroy the recipient's red cells. Since it is important for the donor's plasma to be compatible with the recipient's red cells, table 2 gives the predicted compatibility for donor plasma and recipient red cells. Although severe hemolysis due to an incompatible isoagglutinin is a hazard, the possibility of this taking place is of the order of 5 per cent and should properly be ignored if the risk of not giving plasma is greater. In an emergency, plasma of any ABO group should be given as indicated.

In many patients, the Rh group of the donor may be ignored, but the possibility of causing Rh sensitization in females of child-bearing potential must be considered. In many instances, the difficulty of obtaining Rh negative blood for the production of plasma makes this consideration an academic one.

A number of products are now available with advantages and disadvantages as compared to single donor plasma. Single donor plasma must therefore be viewed as a "homemade" plasma volume expander, and the other products may be compared to it in regard to utility and risk.

Table 3 lists the presently useful and usually available products that are likely to be considered when a plasma volume expander is needed. The relative risk of transmitting hepatitis, causing sensitivity reactions and interfering with crossmatching is indicated for each product, when compared to single donor plasma.

**Fresh Frozen Plasma**

Although fresh frozen plasma is best restricted to the treatment of hemophilia when available in limited amounts, this product is quite useful for other patients. Since fresh frozen plasma contains almost all the normal clotting factors except platelets, infusion of large quantities will not dilute circulating clotting factors. The only major obstacle to considering fresh frozen plasma the ideal plasma volume expander is the risk of transmitting viral hepatitis (homologous serum jaundice).

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**Table 1. Present Commercially Available Plasma Expanders**

<table>
<thead>
<tr>
<th>Product</th>
<th>Cost Per 250 ml Plasma Equivalent</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal human plasma, U.S.P.</td>
<td>$24.00</td>
<td>No coagulation factors.</td>
</tr>
<tr>
<td>Plasma protein fraction, U.S.P.</td>
<td>$20.00</td>
<td>No coagulation factors.</td>
</tr>
<tr>
<td>Serum albumin, U.S.P.</td>
<td>$20.00†</td>
<td>Available conc., salt poor.</td>
</tr>
<tr>
<td>Dextran, U.S.P.</td>
<td>$5.50</td>
<td>1,000 ml administration limit.</td>
</tr>
<tr>
<td>Lactated Ringer's solution, ‡ U.S.P.</td>
<td>$0.80</td>
<td>May substitute for plasma in hypovolemic shock.</td>
</tr>
</tbody>
</table>

* Approximate price January 1, 1966.
† Limited amount available from American Red Cross at $3.00 per equivalent.
‡ Not a plasma volume expander in the literal sense.

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**Table 2. Predicted Compatibility of Donor Plasma with Recipient Red Cells**

<table>
<thead>
<tr>
<th>Plasma of Donor Blood Group</th>
<th>Will be Compatible With Blood of Plasma Recipient Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>A</td>
<td>O, A</td>
</tr>
<tr>
<td>B</td>
<td>O, B</td>
</tr>
<tr>
<td>AB</td>
<td>O, A, B, AB</td>
</tr>
</tbody>
</table>
Where the donor population can be carefully selected this risk may be as low as 0.6 per 1,000, but in other areas it may be much higher. The technique of plasmapheresis has made the production of fresh frozen plasma more convenient than ever before and resulted in a safer and more effective product. However, since other products do not carry the same risk of hepatitis, it would be unwise to use fresh frozen plasma if another safer product provides the same clinical effect.

From the logistical point of view, fresh frozen plasma has major disadvantages since it must be more carefully handled by qualified blood bank personnel, cannot be stored except in a special deep-freeze unit, and poses a delay, for thawing and processing, before it can be administered. Fresh frozen plasma is identical to single donor plasma so far as compatibility considerations are concerned, and the same rules apply for choosing the proper blood group.

Normal Human Plasma, U.S.P.

When plasma is pooled, it can be handled in bulk, the isoagglutinins are neutralized, a product can be prepared which resembles single donor plasma closely, and it can be distributed as a pharmaceutical. Usage of this product declined precipitously after disclosure of the high frequency of contamination with the virus of homologous serum jaundice during World War II. The important contribution of Allen in showing that plasma stored at 32° C. for six months was relatively noninfectious, has again revived the use of pooled plasma on a large scale.

The use of the term plasma for this product is somewhat misleading since by the time the plasma is recalified and stored for six months, all coagulation proteins have vanished and the end product resembles serum more than plasma. The storage procedure undoubtedly denatures normal serum proteins as well as the hepatitis virus, but albumin is rather stable and the final product has most of the oncotic properties of the original plasma.

Because pooled human plasma stored for six months can be handled as a pharmaceutical, it has many of the advantages of the synthetic plasma substitutes and few of the disadvantages. The principal problems are the short supply, relative expense and the fact that it is still not completely free of hepatitis virus. The virus is attenuated rather than destroyed, and many of the patients receiving such preparations can be shown to develop subclinical hepatitis.

Single donor plasma may also be aged in the same manner as the larger pool in order to attenuate the hepatitis virus. Many blood banks have found that their modest scale of usage does not make the use of large pools of plasma convenient. As an alternative, plasma obtained from recently outdated blood can be stored in individual containers, cultured individually, and released for use after the prescribed storage period. This product usually has properties identical to Normal Human Plasma, U.S.P.

Plasma Protein Fraction, U.S.P.

This product can be considered a crude but thoroughly acceptable albumin fraction. A large pool of plasma is partially fractionated.

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<table>
<thead>
<tr>
<th>Product</th>
<th>Source</th>
<th>Transmits Viral Hepatitis</th>
<th>Sensitivity Reactions</th>
<th>Interferes with Cross-Matching</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single donor plasma*</td>
<td>Blood Bank</td>
<td>Occasionally</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Fresh frozen plasma</td>
<td>Blood Bank</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Normal human plasma, U.S.P.</td>
<td>Commercial</td>
<td>Occasionally</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Plasma protein fraction, U.S.P.</td>
<td>Commercial</td>
<td>No</td>
<td>Occasionally</td>
<td>No</td>
</tr>
<tr>
<td>Serum albumin, U.S.P.</td>
<td>Commercial</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Dextran, U.S.P.</td>
<td>Commercial</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lactated Ringer's, U.S.P.</td>
<td>Commercial</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

* Stored for 6 months at 32° C. Otherwise the same risk as fresh frozen plasma.
by the cold-ethanol method to prepare albumin plus several α and β globulin fractions. The final product, unlike Normal Human Plasma can be handled as a pharmaceutical and is entirely free of hepatitis virus. Plasma protein fraction is an ideal plasma expander, but because it is made from plasma it continues to be in short supply and expensive to produce.

There is no advantage when plasma protein fraction is compared to serum albumin and there is the important disadvantage that concentrated plasma protein fraction is not available. Since it is difficult to increase the plasma protein concentration with a 5 per cent solution, the lack of a concentrated solution prohibits the use of plasma protein fraction for this purpose. The major advantage of plasma protein fraction is the low cost of production, but the full impact of this has not yet been felt by the consumer (table 1).

**Serum Albumin, U.S.P.**

Serum albumin offers several advantages when compared with other available plasma expanders. The advantages of serum albumin are that the product may be concentrated five times and made salt poor; it does not transmit homologous serum jaundice, it can be handled as a pharmaceutical more conveniently than the other expanders, and it represents a conservation of starting material since other fractionation products such as gamma globulin can be made as well.

Concentrated serum albumin is more stable than the other plasma proteins and more important in expanding plasma volume since albumin contributes most to the oncotic pressure of plasma. Since serum albumin is less viscous than other plasma proteins, a 25 per cent solution can be used conveniently. Such a concentrated solution can be administered more quickly than any other available plasma expander; for this reason concentrated serum albumin is ideal for the emergency treatment of shock, as long as the patient is not dehydrated. If the patient is dehydrated, additional fluids must be given for the desired effect and albumin loses its advantage.

Unlike the other plasma expanders, serum albumin is effective in the treatment of diseases characterized by severe hypoalbuminemia. Salt poor serum albumin is unique in this application since the other plasma expanders are relatively dilute and contain large amounts of salt. In patients with cirrhosis or nephrosis, serum globulins are usually relatively elevated and albumin can be considered a specific treatment. It is often argued that the effect is only temporary, but since temporary improvement can be crucial, albumin must still be considered lifesaving. In addition, some authors have noted that while albumin is temporarily effective, this may be followed by permanent improvement.

There is ordinarily no dosage limit to infusion of albumin, but large amounts of any fluid lacking in clotting factors may dilute the patient’s clotting factors. For this reason, patients receiving large amounts of albumin for plasma replacement following blood loss may need, in addition, fresh platelet-rich plasma or fresh whole blood if prothrombin levels are low because of dilution. Albumin does not cause the bleeding tendency seen with the use of synthetic colloids such as dextran, but dilution of available clotting factors may accentuate a bleeding tendency already present.

The disadvantages of albumin are merely the expense and scarcity. Serum albumin can be considered the best of the presently useful plasma “substitutes” and should be the first choice. If albumin were less expensive and available in sufficient quantity, no other plasma substitute would be required.

**Dextran, U.S.P.**

In the past 20 years dextran has become the most important plasma expander after serum albumin and the only synthetic plasma substitute which has received wide-spread acceptance in the United States. Dextran is a branched polysaccharide made up of glucose units and is provided at an average molecular weight of about 70,000 in this country. Because dextran is obtained as a result of microbiological synthesis the final product is not uniform. Depending upon the strain of bacterium and the methods used for synthesis, dextrans with varying molecular branching and high or low molecular weights may be produced. While American and Soviet dextran average 70,000, Swedish dextran averages slightly higher and the molecules are more branched. The American bacterial strain produces the least
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A number of branches; this is believed to correlate with a lower incidence of sensitivity reactions. Dextran produced in Britain has a molecular weight from 150,000 to 175,000 and is excreted more slowly than United States dextran.

The advantages of dextran overcome the disadvantages of plasma since it is free of hepatitis virus, inexpensive, and readily available. However, when given in large amounts, dextran causes a coagulation defect and may result in an increased bleeding tendency.9 Relatively large amounts of dextran also interfere with the results of crossmatching since the dextran molecule causes pseudo-agglutination when matching the patient’s serum against donor red cells. This problem is of little moment if a blood sample can be obtained prior to the infusion of the dextran, but in emergency situations, serious delay may ensue in obtaining whole blood if this detail is overlooked. Both the bleeding tendency and the crossmatching problem are usually not serious if not more than 1,000 ml. of 6 per cent dextran are administered.

As in the case of most polysaccharides, dextran can be antigenic and a small number of individuals who have never received dextran are sensitive to it. These individuals may have a severe sensitivity reaction with the first dose of dextran, but it must be admitted that such reactions are rare with the United States product. In those clinical situations that call for dextran administration, the risk of sensitivity must be considered extremely small when compared with the risk of continued circulatory shock.

The metabolic fate of United States dextran has been shown to be primarily that of urinary excretion. Most of the substance is eliminated in the urine within 24 hours and the remainder slowly oxidized over the next 3 to 14 days. Unlike the plasma and protein fractions described above, dextran contributes insignificantly to nutrition. Concentrated dextran has been used to promote diuresis in hypoproteinemia in the same way as serum albumin, but this therapy has not received adequate investigation and a concentrated dextran solution has not been made available.

In the common instances where dextran would be used, that is in hemorrhage or burn shock, dextran is given until whole blood or protein solutions can be obtained. Dextran acts as a substitute until more definitive treatment can be given.

Low Molecular Weight Dextran

Since dextran is a chain polysaccharide, it is possible to prepare smaller molecules than those supplied in the standard commercial solution. Dextran of low molecular weight has many interesting therapeutic uses since dilute solutions tend to reverse erythrocyte “sludging” in vivo.10 Such sludging occurs in many diseases but can also be observed in refractory shock. Low molecular weight dextran does not remain in the circulation as long as the standard commercial dextran, but does provide short-term plasma volume expansion and thus may be said to produce two beneficial11 effects. This type of dextran has no more disadvantages than the standard dextran, and although not yet approved by the Food and Drug Administration this is expected in the near future.

Other Plasma Volume Expanders

While dextran is an accepted synthetic plasma volume expander, many other synthetic colloids have been investigated and the search for a better synthetic plasma volume expander continues. Table 4 lists some of the many substances that have been proposed for this purpose at one time or another. Most of these preparations have been discarded and further comment will be restricted to hydroxethyl starch, gelatin and polyvinylpyrrolidone.

Hydroxethyl starch is the most promising of the recently studied compounds,13 but it has not been tested in any large clinical trial. The

Table 4. Colloid Substances Proposed as Plasma Volume Expanders

<table>
<thead>
<tr>
<th>Substance</th>
<th>Source</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia</td>
<td>Plant</td>
<td>Toxic, stored13</td>
</tr>
<tr>
<td>Alginin</td>
<td>Seaweed</td>
<td>Ineffective12</td>
</tr>
<tr>
<td>Animal protein</td>
<td>Carrot, horse</td>
<td>Serosum sickness</td>
</tr>
<tr>
<td>Casein</td>
<td>Milk</td>
<td>Antigenic14</td>
</tr>
<tr>
<td>Gelatin</td>
<td>Animal bones</td>
<td>Gels at room temp,16</td>
</tr>
<tr>
<td>Globin</td>
<td>Hemoglobin</td>
<td>Synthesis</td>
</tr>
<tr>
<td>Glutamyl peptide</td>
<td>Surghum starch</td>
<td>Toxic13</td>
</tr>
<tr>
<td>Hydroxyethyl starch</td>
<td>Fish gelatin</td>
<td>Promising15</td>
</tr>
<tr>
<td>Isinglass</td>
<td>Fish gelatin</td>
<td>Antigenic16</td>
</tr>
<tr>
<td>Metyl cellulose</td>
<td>Fish gelatin</td>
<td>Toxic17</td>
</tr>
<tr>
<td>Oxypoly gelatin</td>
<td>Fish gelatin</td>
<td>Promising18</td>
</tr>
<tr>
<td>Peroxid</td>
<td>Fish gelatin</td>
<td>Stored in tissues20</td>
</tr>
<tr>
<td>Polyvinylpyrrolidone</td>
<td>Fish gelatin</td>
<td>Stored in tissues21</td>
</tr>
<tr>
<td>Polyvinyl alcohol</td>
<td>Fish gelatin</td>
<td>Stored in tissues22</td>
</tr>
</tbody>
</table>
structure of hydroxyethyl starch bears a resemblance to dextran, but the starch derivatives can be produced more easily and inexpensively. The similarity of starch derivatives to some body constituents normally present may be one reason to expect minimal toxicity or antigenicity with the use of this product.

Gelatin is prepared from bovine collagen, is relatively non-antigenic, and has been shown to have the same effect as plasma when administered intravenously. The outstanding disadvantage of gelatin is the tendency to gel at room temperature, and the need therefore to warm it to 37°C before administration. In addition to this problem, gelatin solutions (like dextran and polyvinylpyrrolidone) cause marked rouleaux formation of red cells and interfere with crossmatching.

Surprisingly few reactions have been reported after the use of gelatin intravenously and this product once was listed in New and Non-Official Remedies. Although oxidized gelatin has been prepared, with the same clinical value as gelatin but without the tendency to gel, large-scale clinical testing has not been carried out with this product. At present, gelatin is not available in the United States since the only commercial supplier ceased to market this product in 1958. Gelatin derivatives are presently available in Switzerland and France.

Polyvinylpyrrolidone received considerable attention during and after World War II when it was used extensively in Germany. Despite a large European experience with this plasma substitute, it is not an approved product in the United States. The American Drug Index apparently listed this product in error during 1964 since the original United States supplier withdrew the product a number of years ago. Polyvinylpyrrolidone never received official approval because of its metabolic fate. When polyvinylpyrrolidone solutions are administered intravenously, much of the polyvinylpyrrolidone is stored indefinitely in the tissues. While the German experience did not suggest harm from such storage, this feature is considered undesirable, especially when another product (dextran) is available.

Although neither gelatin nor polyvinylpyrrolidone is presently available except for investigational use, it should be remembered that they achieved widespread clinical use in the past. These products were in fact, the best synthetic plasma substitutes prior to dextran, and their use should be considered again if ever dextran cannot be obtained.

Buffered Saline

Solutions of sodium chloride were proposed as blood substitutes toward the end of the nineteenth century; a considerable variety of hypotonic, isotonic, and hypertonic sodium chloride solutions were formulated, and even sterilized sea water was used in the hope it would be beneficial. It soon became obvious that noncolloid solutions leave the circulation rapidly and that any plasma volume expansion is transient. Further investigation indicated that when saline is given in quantities equal to the volume of blood lost, correction of hypovolemia does not occur. Until recent years, the infusion of large amounts of saline was considered for the treatment of shock or burns only when colloid could not be obtained.

More recent investigation has indicated that in shock associated with burns, tissue injury or hemorrhage, a decrease in plasma volume is not the only serious physiologic disturbance. In addition to the plasma lost in external hemorrhage, the volume of extravascular, extracellular fluid decreases. Extracellular fluid is mobilized in an attempt to restore intravascular fluid volume. The loss of extravascular fluid results in a partial loss of intracellular fluid since these two fluid compartments are in equilibrium. If a lowered plasma volume is not restored promptly, the lack of sufficient volume in the extravascular compartment adversely affects cellular function. Even if plasma volume is ultimately restored, the cells engaged in the transport of fluid are unable to replete the extravascular compartment, and shock continues. The fact that shock becomes refractory if not treated promptly is well known, but this explanation was not forthcoming until recently. Additional factors such as liberation of endotoxins have also been proposed, and it is also clear that shock results in a metabolic acidosis.

In order to correct the deficit of extravascular fluid, salt and water must be given as well as a solution that will remain in the
intravascular compartment. Since metabolic acidosis is usually present and since ordinary salt solutions are slightly acid, lactated Ringer's solution is considered the proper formulation to correct the extravascular fluid deficit. It must be emphasized however, that lactated Ringer's solution is not the only possible formulation. A combination of "normal" saline and sodium bicarbonate is equally efficacious and there is evidence that it is the water and sodium content of these solutions which is most important. One investigator has shown that even if anuria and acidosis are corrected, mortality in experimental hemorrhagic shock is not improved unless adequate volumes of sodium containing fluids are administered.  

Shock associated with extensive burns is similar but not identical to the shock resulting from hemorrhage. Whole blood is not usually lost during burning, but the burned area does sequester water, salt and plasma protein. The amounts removed from circulation may be large and lead to a general deficit in extravascular fluid. The condition is similar to that in hemorrhagic shock except that there is less immediate loss of red cell volume and the plasma is lost into the burned area, rather than externally. The traditional treatment for burn shock dictated the use of plasma, but recent observations indicate that lactated Ringer's solution may substitute for at least some of the plasma. Moreover, at least one group of investigators has emphasized that in burns, the deficit of mobilizable water and electrolytes may be more important than the deficit of circulating protein. Accordingly, it may be possible to reduce the use of protein containing solutions to a minimum in treating burns. Lactated Ringer's solution has been the fluid most commonly advocated to correct burn shock in place of plasma, and successful treatment of burn shock has been reported with Ringer's solution alone.

**Tris Buffer**

Tris-(hydroxymethyl) aminomethane (THAM) buffer is a saline solution containing organic buffer rather than the inorganic buffers represented in lactated Ringer's solution. In addition to ameliorating the acidosis contributing to shock, Tris buffer produces an osmotic diuresis similar to mannitol. This diuretic property would seem to confer an advantage over the inorganic buffers, but again, it has been demonstrated that unless adequate volumes of sodium and water are given, the correction of acidosis and initiation of diuresis will not be beneficial. As is the case of mannitol, sodium containing solutions must be given to support the diuresis and to avoid oliguria resulting from hyponatremia.

Tris buffer has not yet received F.D.A. approval and is not available for routine use. Investigations and long term studies are now in progress but it is not expected that Tris buffer will be available in the near future. Tris buffer requires great care in administration since it is a powerful respiratory depressant, and other pharmacologic disadvantages have been reported as well.

Buffered saline solutions should not be considered plasma volume expanders, rather extravascular fluid expanders. Since they are given for the same indications and perhaps along with or in place of true plasma expanders, some may be lead to believe that buffered saline solutions are plasma substitutes. These solutions may replace plasma expanders and they may secondarily increase plasma volume, but they have a different action and effect when compared to the colloids. Unless the physician using these solutions clearly understands their purposes, the patient is bound to suffer.

**Summary**

The presently useful plasma expanders are: plasma, plasma protein fraction, serum albumin and dextran. Fresh frozen plasma is unique among these agents in that it contains the plasma clotting factors. Serum albumin is unique in that the concentrated solution is rapidly effective in shock and also restores plasma oncotic pressure in hypoalbuminemia. Concentrated serum albumin offers all of the properties of an ideal plasma volume expander. Were enough available, it would not be necessary to produce any form of plasma other than fresh frozen plasma.

Dextran is the only commercially available synthetic plasma expander approved for use in the United States. It has gained wide acceptance despite the disadvantages of occasional allergic reactions, crossmatching inter-
ference, and prolongation of bleeding time. Low molecular weight dextran currently under investigation is superior to the present clinical preparation in that it may reverse the erythrocyte sludging seen in prolonged shock.

Recent investigations on hypovolemic shock (hemorrhage and burns) have indicated the importance of extravascular fluid deficits in “irreversible” shock. Restoration of extravascular water and electrolytes and correction of acidosis are best accomplished with the use of buffered saline solutions. Proper use of buffered saline (lactated Ringer’s solution) may greatly reduce the amount of traditional plasma volume expanders given in hypovolemic shock. When hypovolemic shock is prolonged, resuscitation may not be successful unless buffered saline is administered in adequate quantity.

References


