Significance of Homologous Donor Blood to the
Toxic Reaction in Dogs Undergoing
Extracorporeal Hemodialysis

By FRANK T. MAHER, M.D., LEE C. WATKINS, JR., M.D.,
JAMES C. BROADBENT, M.D. AND JESSE L. BOLLMAN, M.D.

With technical assistance of Samuel R. Amandson and Betty Hennessey

Application of hemodialysis to dogs has been complicated by an acute reaction consisting of hypotension, bradycardia, and respiratory depression followed by instability and a mortality rate of about 30 per cent. This reaction appears to be a response to homologous blood used to fill the dialyzers. Sensitization occurs in survivors, and accentuated reactions with marked hemolysis are noted on subsequent challenge. Cross matching the donor and recipient bloods has not permitted an adequate determination of compatibility under the conditions of hemodialysis. Satisfactory hemodialysis may be accomplished in dogs by using autogenous blood or blood substitutes to fill the dialyzers.

We have frequently noted a toxic reaction pattern occurring in dogs anesthetized with pentobarbital sodium and subjected to extracorporeal hemodialysis with the Skeggs-Leonards-Heisler "artificial kidney." This reaction is associated with considerable morbidity, and many such dogs die during or shortly after the procedure. Similar reactions, though quantitatively less severe, have been noted in 7 of 23 therapeutic hemodialyses employed in the management of renal failure in patients.

Using minor modifications of the procedure described by Skeggs, Leonards and Heisler, we have noted in most dogs an initial hypotensive reaction, associated with bradycardia and respiratory depression. Severe urticarial lesions occasionally appear, widespread over the ventral aspect of the body. Leukocyte and platelet counts fall dramatically at the onset of the procedure, usually to less than 10 per cent of the original value within the first 5 min. of dialysis.

Recovery from this reaction pattern is usually incomplete. The subsequent course during 3 to 6 hours of hemodialysis is irregularly hypotensive and unstable in most instances, and severe secondary periods of hypotension may occur in the absence of a marked initial reaction. Twenty-nine of 30 dogs died following the procedure. Similar reactions have been noted by others.

We have been unable to confirm the work of Skeggs and associates and of others ascribing this toxicity to substances present in the cellophane membranes used, and removable by prolonged periods of treatment in boiling water. We have been unable to improve the procedure consistently by any available methods for processing the cellophane sheets, or by the use of cellophanes prepared by different commercial methods. We have, therefore, extended our study to other components of the procedure of hemodialysis.

In describing the application of the original "artificial kidney" to 22 dogs, Abel, Rowntree and Turner did not note any unusual reactions, and described prompt and complete recovery in their dogs following the procedure. Their apparatus made use of collodion membranes, and no donor blood or other material was used to fill the dialyzer prior to extracorporeal circulation.

The volume of the extracorporeal blood
path using the Skeggs-Leonards-Heisler apparatus approximates 500 ml. with the dialyzers of 12 units as commonly used. Packs of 6 units reduce this volume to about 250 to 300 ml. The dialyzer pack is filled with donor blood, and, in the usual procedure, the onset of dialysis is marked by the transfusion of 250 to 500 ml. of donor blood in 2 to 5 min. Slower rates of blood flow at the start may lessen the severity while prolonging the span of the initial reactions noted in dogs, without appreciably improving the response of the animals to the total procedure.

The presence of an antigen-antibody framework in dog blood has been described by several investigators, and may well form the basis for reactions due to incompatible blood, particularly in large transfusions given rapidly. Young, Swisher and co-workers have described 10 or more blood groups in dogs based on antigens contained in their erythrocytes. These have been identified arbitrarily as A, B, C, D, E, F, G, ..., in the order of recognition in Young and Swisher's laboratory, and bear no known relationship to antigens present in man or in other animals. Multiple antigens are commonly encountered. In a group of 138 random dogs, 40 exhibited two erythrocyte types, 62 had three types, 17 had four types, and 8 had five types. The A factor was present in 63 per cent of this group, and the C antigen was identified in 98 per cent. Only 11 dogs in the group exhibited a single erythrocyte type. Naturally occurring isoantibodies were found in the sera of only 22 of 145 dogs, and in none of these did the titer exceed 1:8. These authors noted that antigenicity is associated particularly with erythrocytes of A and C types, and that A type cells in particular lead to the production of agglutinins and hemolysins when transfused into dogs of A- types.

Young and his associates have concluded that the routine use of A- dogs as donors should eliminate most of the hazards of transfusion to dogs, and that cross-matching techniques would probably add little to the safety of transfusion. They calculated that 25 per cent of random transfusions may lead to the production of anti-A in the recipients, and that 15 per cent of dogs transfused a second time against random homologous donors will have been sensitized, and will thus receive incompatible blood.

Ferguson has reviewed the literature on blood groups in animals and finds similar problems in the other common laboratory, domesticated and agricultural animals. In these, as in dogs, practical application seems limited by a lack of data in critical areas.

We have sought to evaluate the effects of homologous donor blood introduced into dogs undergoing hemodialysis, and the possible significance of these to the toxic pattern noted in these dogs. Results obtained in this study indicate that the toxic reactions are due primarily to incompatibility with the donor blood used in filling the dialyzing packs.

**METHODS**

Our earlier series of hemodialyses in dogs was carried out by the procedure of Skeggs, Leonards and Heisler. The prepared dialyzer pack was filled directly with homologous donor blood, and connected by rubber or plastic tubing to the cannulas, placed, with the animal under pentobarbital sodium anesthesia, in a femoral artery and femoral vein of the dog to be dialyzed. With a suitable dialyzing fluid flowing through the pack, a dialysis was begun by removing the clamps from the cannulas and starting the blood pump. By this method, onset of dialysis and the introduction of the donor blood are simultaneous events and their individual significance to subsequent behavior cannot readily be assessed.

In a current series of 15 dogs hemodialyzed by the same procedure, initial hypotensive reactions were noted in all. Of these, 13 were moderate to severe in degree, and 5 of these 15 dogs died during dialyses or within 48 hours after the procedure. This represents some improvement over the initial control series, due to chance selection or conceivably to progressive, nonspecific advances in technic and procedure.

**Group I. Hemodialysis: Dialyzer Primed with Autogenous Blood.** Each of 6 dogs was subjected to hemodialysis by the foregoing procedure, but

---

*We are indebted to Dr. L. E. Young and to Dr. S. N. Swisher, University of Rochester School of Medicine, for supplies of anti-A, anti-C, and anti-D typing sera and for suggestions helpful to the conduct of this study.*
using packs filled with autogenous blood. This blood was drawn from the dog on the day preceding dialysis, heparinized and refrigerated overnight. On the following day, dialyses were instituted and conducted in the usual manner for approximately 5 hours.

No reactions were observed. Dialysis proceeded uneventfully in each dog, and all recovered normally despite the associated net loss of blood discarded with the packs at the end of the procedures. In subsequent studies, this pack blood has been returned to the animals without evidence of untoward reaction.

**Group II. Hemodialysis: Dialyzer Filled with a Blood Substitute.** Dogs included in this group were hemodialyzed by the control procedure described, using dialyzers filled with a blood substitute.

For each of 5 dogs, the dialyzer was filled with isotonic solution of sodium chloride. No severe or typical initial reactions were noted following the onset of dialysis. Blood pressure tended to sag in each case as dialysis proceeded, and this was pronounced in 1 dog. One of the dogs died on the second postdialysis day.

For each of 14 dogs, the dialyzer was filled with a 6 per cent solution of dextran in isotonic sodium chloride solution. No initial reactions were noted. A delayed sag in blood pressure occurred in 4 dogs. All of the 14 dogs in this group recovered.

In 5 additional dogs, a similar procedure was carried out, but in these cases loss of weight due to ultrafiltration was replaced with the dextran solution rather than with the salt solution usually infused for this purpose. An average of 460 ml. of dextran solution was infused during dialyses of approximately 5 hours each. No initial reactions were noted and blood pressure was well maintained during dialysis in each case. Four of these dogs were in excellent condition the following morning. One dog died overnight following an uneventful dialysis. This dog experienced an unusually severe hypotensive episode following the administration of protamine sulfate at the end of dialysis.

Each of 5 dogs, anesthetized and cannulated as usual, was given an infusion of 500 ml. of isotonic sodium chloride solution in exchange for an equal volume of blood. All of these dogs survived, although moderately severe hypotension was observed in 3 instances.

Each of 6 dogs similarly received an infusion of 500 ml. of 6 per cent dextran in isotonic sodium chloride solution in exchange for 500 ml. of blood. No initial reactions were observed. One dog became moderately hypotensive later in the observation period. Each of the 6 dogs survived the procedure.

No differences in degree of reaction could be observed between the dogs receiving only the exchange infusion of saline solution or of dextran solution and the dogs subjected to hemodialysis following the exchange transfusion of these solutions.

**Group III. Sham Studies.** Each of 6 dogs was anesthetized with pentobarbital sodium, immobilized supine on the operating table and cannulated by the usual technics. They were observed for 5 hours, receiving the usual doses of heparin, and increments of pentobarbital sodium as needed. They were then decannulated and observed for a period of 2 weeks. No toxic reactions were noted, and all dogs remained in good condition during and following the sham procedure.

Each of 2 dogs was cannulated by the usual technics. An extracorporeal circuit was maintained for 5 hours, including only the blood pump, flow meter and trap in the blood path between the arterial supply and the venous return, and incorporating no donor blood. No adverse reactions were noted, and these dogs recovered normally.

Each of 2 additional dogs was similarly prepared. Each received 500 ml. of homologous donor blood through the venous cannula, and an equal volume was removed at the same rate from the arterial cannula. This balanced exchange transfusion was completed in 3 to 5 min. An extracorporeal circuit was then established as above, and maintained for 5 hours. One of these dogs had a severe hypotensive reaction to the blood given, and recovered sluggishly. The other dog had no grossly observable reaction to the procedure and recovered normally.

**Group IV. Hemodialysis: Dialyzer Filled with Homologous Blood by Exchange Transfusion.** Each of 17 dogs was prepared for dialysis as usual. The washed, saline-filled dialyzer packs were filled by displacement with arterial blood from the dog to be dialyzed, taken through the arterial cannula and the blood pump of the completed assembly. Homologous donor blood was infused simultaneously into the venous cannula at the same rate, and the entire process was completed in 3 to 5 min. On completion of the exchange, the venous outflow tubing from the pack was connected to the venous cannula to complete the circuit in readiness for hemodialysis. A period of 20 min. was allowed for the observation of reactions and for recovery from reaction to the blood given. Hemodialysis was then instituted and completed in the usual manner.

Initial hypotensive reactions occurred in 7 of these 17 dogs during the exchange period. Five other dogs became moderately hypotensive during the dialysis. Two dogs died overnight, another died on the second day, and a fourth died on the fourth day following hemodialysis. The course of the procedure was in general more stable and the survivors recovered more quickly and more com-
<table>
<thead>
<tr>
<th>Blood types</th>
<th>Recipient dog</th>
<th>Donor dog of dogs</th>
<th>Cross-match results</th>
<th>Reactions and course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>A−</td>
<td>A+</td>
<td>A+</td>
<td>Major agglutination</td>
<td>Moderate initial hypotension; steady course; good recovery</td>
</tr>
<tr>
<td>A−</td>
<td>A+</td>
<td>A+</td>
<td>Major agglutination</td>
<td>Severe initial hypotension; unstable course; severe hemolysis; died</td>
</tr>
<tr>
<td>AC</td>
<td>AC</td>
<td>AC</td>
<td>Major micro-agglutination</td>
<td>Minimal initial reaction; steady course; uneventful recovery</td>
</tr>
<tr>
<td>Unknown</td>
<td>Unknown*</td>
<td>AC</td>
<td>Not done</td>
<td>Transfusion received well</td>
</tr>
<tr>
<td>A−</td>
<td>A−</td>
<td>AC</td>
<td>Compatible</td>
<td>No adverse reaction; uneventful dialysis and recovery</td>
</tr>
<tr>
<td>A−</td>
<td>Unknown</td>
<td>A+</td>
<td>Compatible</td>
<td>Moderate initial hypotension; fair dialysis with moderate hypotension; severe hemolysis; poor recovery</td>
</tr>
</tbody>
</table>

*Transfusion only.

Table 1: Accentuated Reactions to Homologous Blood and Hemodialysis Following Previous Exposure to Homologous Blood

Four additional dogs were hemodialyzed in similar fashion, against dialyzing packs filled by exchange infusion with washed, saline-suspended homologous erythrocytes. Initial hypotensive reactions occurred in 2 of these, and terminated fatally. Four dogs were similarly dialyzed against packs filled by exchange infusion with separated homologous plasma. Severe initial hypotensive reactions occurred in 2 of these, 1 of which died shortly after the end of dialysis.

In 5 dogs, the procedure was limited to the exchange transfusion of 500 ml. of homologous donor blood as described above. Four of these dogs exhibited initial hypotensive reactions to this balanced exchange, and these reactions were severe in 3 instances. All animals survived, following rather prolonged recovery periods.

Group V. Sensitization: Repeated Hemodialysis Using Homologous Donor Blood. In our earlier experience with random donor dogs we encountered particularly severe reactions in attempting hemodialysis using dogs that had previously received homologous blood. Young and associates have estimated that 15 per cent of such dogs will have been sensitized by the previous experience.

Each of 5 dogs was subjected to hemodialysis by the technic of exchange transfusion using homologous blood to fill the dialyzer pack. A sixth dog in this group received homologous transfusion only. Three or 4 weeks later each dog was again transfused by exchange with homologous blood and was then hemodialyzed for periods of 3 hours or more. The severity of reactions occurring during the first and the second procedures is compared in table 1.

In one dog, conditions were established to provide donor dog blood which would be high in anti-A antibody. This donor dog of type C was hemodialyzed using type A blood to fill the dialyzer pack by exchange transfusion. The course of this dialysis was marked only by a slight sag in blood pressure, with excellent recovery. Cross-matching revealed only microagglutination of the
donor cells in the recipient plasma. Two weeks later, plasma of this dog agglutinated grossly with type A erythrocytes.

Three weeks after the foregoing dialysis, this dog served as the donor for hemodialysis applied to a dog of type ACD. Presence of antibody in the donor plasma was indicated by a gross agglutination of recipient cells by donor plasma; no agglutination of donor cells occurred in recipient plasma. This ACD dog became severely hypotensive during exchange transfusion of this donor blood. The course of hemodialysis was unstable and hypotensive, with the death of the dog occurring at 3 hours. Marked hemolysis was noted in the mixed bloods shortly after the transfusion, and this increased in severity during the 3 hours of extracorporeal circulation.

Further attempts to improve hemodialysis in dogs by the use of pooled dog plasma, pooled, washed and saline-suspended erythrocytes, or pooled homologous blood have led to inconsistent and unsatisfactory results. Uneventful procedures may be noted occasionally, despite incompatibilities in type or cross-match. In each group severe reactions have been noted, and these may lead to the death of the dog during or shortly after the procedure.

Group VI. Hemodialysis Using Homologous Blood: Pretreatment with Drug Agents. Numerous attempts have been made to counteract the toxic reactions noted in dogs by the use of drugs whose pharmacologic actions might be antagonistic to the effects noted. Thus, we found that the prophylactic or corrective use of norepinephrine aided recovery and lowered morbidity and mortality in the dogs so treated. Temporary use of norepinephrine has also been considered useful in combating the hypotension which occurred in 7 of our 23 hemodialyses carried out in human patients.

Each of 5 dogs was subjected to hemodialysis, employing homologous donor blood by exchange transfusion. Each procedure was preceded by the intravenous administration of piperoxan in doses of 2 mg./Kg. body weight. The phenomenon of epinephrine reversal was demonstrated in each dog prior to the exchange transfusion and the onset of dialysis. Minimal reactions occurred in 2 of these dogs. All recovered quickly, and dialysis then proceeded uneventfully in each case. Blood pressures were well maintained, and all animals remained in excellent condition during and after the procedure.

Atropine, diphenhydramine, cortisone, and corticotropin have been used, singly and in combination, in attempts to neutralize possible factors underlying the reactions to homologous blood. A consistent protective action has not been demonstrable.

Typing and Cross-Matching Studies. We have subsequently used the procedures of Young and associates for typing and cross-matching many of the recipient-donor pairs involved in transfusion and hemodialysis.

The possibility that reactions could be avoided by the routine use of A- donors was examined in a series of 10 dogs. Cross-matches were not done. In 4 instances, A- donor blood was given by transfusion and hemodialysis to A+ recipient dogs. Moderate to severe reactions occurred in 2 dogs, and 1 of these died. No reactions were observed in the other 2 dogs which recovered in normal fashion. In 6 instances, A- donor blood was given by transfusion and hemodialysis to A- recipient dogs. Severe reactions occurred in 3 of these dogs and 2 died. A moderate reaction occurred in 1 dog, in the other 2 moderate hypotension occurred during the course of dialyses; these 3 dogs subsequently recovered without further incident.

Technically satisfactory cross-matches have been completed for 37 dogs subjected to transfusion and hemodialysis using homologous donor blood. These were done in plasma, using 3 per cent erythrocyte suspensions, allowing the plasma-erythrocyte mixtures to incubate at room temperature for 15 min., and centrifuging the mixtures at 700 r.p.m. for 1 min. Agglutination was estimated by gross in-

---

**Table 2.**—Typing and Cross-matching Relationships, and Severity of Reactions Noted in 17 Dogs Undergoing Transfusion and Hemodialysis

<table>
<thead>
<tr>
<th>Blood types (A- or A+)</th>
<th>Cross-matching results</th>
<th>Number of recipient dogs</th>
<th>Number exhibiting marked reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-</td>
<td>Compatible</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>A-</td>
<td>Major agglutination</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>A-</td>
<td>Minor agglutination</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>A-</td>
<td>Compatible</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>A+</td>
<td>Major agglutination</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>A+</td>
<td>Minor agglutination</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>A+</td>
<td>Compatible</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>A+</td>
<td>Major and minor agglutation</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>A+</td>
<td>Minor agglutination</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

---

The possibility that reactions could be avoided by the routine use of A- donors was examined in a series of 10 dogs. Cross-matches were not done. In 4 instances, A- donor blood was given by transfusion and hemodialysis to A+ recipient dogs. Moderate to severe reactions occurred in 2 dogs, and 1 of these died. No reactions were observed in the other 2 dogs which recovered in normal fashion. In 6 instances, A- donor blood was given by transfusion and hemodialysis to A- recipient dogs. Severe reactions occurred in 3 of these dogs and 2 died. A moderate reaction occurred in 1 dog, in the other 2 moderate hypotension occurred during the course of dialyses; these 3 dogs subsequently recovered without further incident.

Technically satisfactory cross-matches have been completed for 37 dogs subjected to transfusion and hemodialysis using homologous donor blood. These were done in plasma, using 3 per cent erythrocyte suspensions, allowing the plasma-erythrocyte mixtures to incubate at room temperature for 15 min., and centrifuging the mixtures at 700 r.p.m. for 1 min. Agglutination was estimated by gross in-
specimen, and those specimens considered negative were examined microscopically for confirmation or for microagglutination.

Compatible cross-matches were observed in 14 of these 37 procedures. Moderate to severe reactions occurred in 7 of these following transfusion and dialysis. In the remaining 7 dogs, no reactions or minimal reactions were observed and these dogs recovered normally. Cross-matching indicated incompatibility in 23 instances. Moderate to severe reactions occurred in 20 of these following transfusion and dialysis. In 3 dogs, no reactions or minimal reactions were observed and these dogs recovered normally.

Typing data with respect to presence or absence of A antigen in donor and recipient are available for 17 of these cross-matched pairs. These relationships were compared to the reactions noted (table 2).

**Discussion**

These studies support our conviction that the adverse reactions described in dogs submitted to hemodialysis are due primarily to the homologous donor blood commonly used in filling the dialyzer packs. This incompatibility may appear in an initial dialysis and may not bear out predictions based on available procedures for estimating compatibility by typing and cross-matching donor and recipient bloods. The problem is particularly vexing in relation to proposed studies of longer duration and requiring repeated dialyses, since dogs successfully withstanding an initial hemodialysis may in our experience be susceptible to more severe reaction on subsequent challenge. Consistent use of A- dog donors has not, in our hands, borne out the conclusions of Young and co-workers, since in our series of 10 hemodialyses using A- donors, 3 deaths were recorded, and moderate to severe reactions occurred in 7 of 10 recipients. This seeming discrepancy may well be due to the rapid infusion of larger volumes of donor blood into our dogs.

Incompatibility noted in cross-matching donor and recipient bloods justified the prediction of moderate to severe reaction in 20 of 23 such examples. On the other hand, compatibility by cross-matching was followed by lack of reaction in only 7 of 14 such recipients and affords no indication of their response to projected subsequent dialyses.

For acute experimentation, single dialyses may be conducted successfully in dogs by 1 of several procedures which avoid the use of homologous donor blood. Autogenous blood or dextran solutions may be used for this purpose. Each of these introduces physiologic disturbances which must be interpreted in terms of the purpose of the hemodialysis contemplated. Use of homologous blood for individual dialyses appears to be feasible in dogs prepared with doses of piperoxan sufficient to provide adrenergic blockade. Other blocking agents have failed to provide this protection and the value of piperoxan for this purpose may be related to the tachycardia which follows its use or to pharmacologic activity unrelated to the phenomenon of adrenergic blockade.

The possible significance of the changes observed in the leukocyte and platelet counts of dogs undergoing experimental hemodialysis has not been clarified. Both leukocytes and platelets may fall to less than 10 per cent of original levels within 5 min. after the introduction of donor blood or the onset of dialysis. Many dogs continue to exhibit leukopenia and thrombocytopenia for the duration of dialysis; in others, counts rise slowly to approximately original values. These changes cannot be correlated as yet with the response or subsequent course of the procedure. We have not been able to locate leukocytes or platelets by microscopic study of the cellophane sheets used, and indeed have found similar leukopenia and thrombocytopenia following exchange transfusions with homologous blood, with blood substitutes, or with autogenous blood. A similar fall in leukocyte count has been observed at the onset of therapeutic dialyses in patients.

Dogs which received homologous blood or blood substitute by exchange transfusion or by hemodialysis commonly exhibited anemia following the procedure. Hematocrit values were reduced in each of these groups to as low as 70 per cent of the control value. Gradual improvement was noted in surviving dogs, with the hematocrit values at the end of 15 days of observation falling generally in the
range of 85 to 100 per cent of control values. In hemodialyses in which autogenous blood was used to fill the dialyzer, predialysis hematocrit values averaged 62 per cent of the values preceding the venesection of the previous day. These values rose slowly during dialysis, and reached an average of 78 per cent of the control hematocrit values by the fifteenth day of observation. Principal factors in the development of these anemic states are probably loss of blood incident to use of blood substitutes or venesection, destruction of incompatible donor blood, and common factors of trauma incident to anesthesia and cannulation.

The procedure of filling the dialyzer pack by exchange transfusion with blood or blood substitute is recommended for experimental hemodialysis, though our procedure for application to patients remains as previously described. By exchange transfusion prior to dialysis, effects due to priming materials may be isolated and recognized. Some improvement in the stability of dogs during dialysis and in their subsequent recovery may result, though over-all mortality remains essentially unchanged.

**SUMMARY**

Most dogs subjected to extracorporeal hemodialysis exhibit a toxic reaction pattern when homologous donor blood is used to fill the dialyzer. The reaction is characterized initially by bradycardia, hypotension and respiratory depression. The subsequent course is often unstable, recovery is uncertain, and mortality may exceed 30 per cent.

The dependence of this reaction pattern on incompatibility between the blood of the dog undergoing dialysis and the homologous donor blood is indicated by: (1) Occurrence of the reaction to a similar degree in experiments limited to the exchange transfusion of homologous donor blood, (2) lack of reaction to hemodialyses employing autogenous blood to fill the dialyzer, (3) lack of reaction to blood substitutes in hemodialyses conducted by the usual procedures but using isotonic saline solution or dextran solutions to fill the dialyzer, and (4) accentuated reactions which occur when a second transfusion and hemodialysis is carried out 3 to 4 weeks after an initial transfusion or hemodialysis employing homologous blood. Reactions of the type described have been seen only in experiments incorporating the use of homologous donor blood.

Satisfactory to uneventful dialyses may be achieved by the use of autogenous blood or of dextran solutions to fill the dialyzer packs.

Dialysis may be successfully accomplished following adrenergic blockade with piperoxan, when this does not negate the intent of the proposed hemodialysis. The effect of this procedure on subsequent sensitization has not been determined. Moderate to severe reactions occurred in 7 of 14 recipient dogs whose bloods were compatible by cross-match with their homologous donors, and in 20 of 23 dogs whose bloods were incompatible with their donors. Severe reactions occurred in 7 of 10 dogs receiving A— homologous blood, and 3 of these dogs died. Severe reactions have been noted in the transfusion of homologous dog blood when the A antigen was detectable in the erythrocytes of both donor and recipient, or was lacking in either or both of these.

**Summario in Interlingua**

Canes subjicite a hemodialyse extracorporee exhibit generalmente un reaction de toxicitate quando sanguine homologe ab un donator es usate pro plenar le dialysator. Le reaction es characterizate inicialmente per bradycardia, hypotension, e depression respiratori. Le curso subsequente es frequenteinete instabile. Le restablimento es incert, e le mortalitate excede a vices 30 pro cento.

Le dependencia de iste configuration de reac- tiones ab le incompatibilitate del sanguine del can subjicite al dialyse con le sanguine homologe del donator es indicate (1) per le occurrentia del mesme reaction a grados comparabile in experimentos restringite al transfusion de exambio con sanguine homologe de donator, (2) per le absentia del reaction in hemodialyses efectuate con sanguine autogene in le dialysator, (3) per le absentia de reac- tiones a substitutos de sanguine in hemodialy- ses effectuate secundo le metodo costumari
except that a solution isotonic of saline or dextrose is used on the dialyzer, and (4) for the occurrence of reactions accentuated when a second transfusion and hemodialysis are performed on two or more days following the initial transfusion or hemodialysis.

Reactions of this type were observed only in experiments where the same blood donor was used.

Dialyses without incident or with minor difficulties were performed successfully by using autologous blood or solutions of dextran to perfuse the dialyzer.

The administration of adrenergic blocking agents, such as propranolol, was possible when this was compatible with the objective of the hemodialysis procedure. The effects of this procedure on subsequent sensitization phenomena have not been determined.

Reactions of intermediate severity occurred in 7 out of 14 dogs with blood that was compatible with the donor's blood, and in 20 out of 23 dogs with blood that was incompatible with the donor's blood. Reactions of severe severity occurred in 7 out of 10 dogs who received blood that was compatible with the donor's blood, and in 3 out of 10 dogs.


dialog*se effectuate with bon sucesso post bloage adrenergic per medio de piperoxano, providite que isto es compatible con le objectivo del manovra hemodialytic. Le effecto de iste procedimento super le pheno-mecono del sensibilisation subsequente ha non essite determinate. Reactiones de grados moderate o sever occurreva in 7 ex 14 canes con sanguine demonstrate compatible con le sanguine de lor donatores homologe e in 20 ex 23 canes con sanguine incompatibile con le sanguine de lor donatores. Reactiones de godo sever occurreva in 7 ex 10 canes recipi-ente sanguine homologe a A— e 3 de istos mo-riva. Sever reactiones ha essite notate in le transfusion de homologe sanguines canin quando le antigeno A esseva detegibile in le erythrocytos del donator e del recipiente o quando illo esseva absent in le erythrocytos de un de illos o de ambes.

REFERENCES


Significance of Homologous Donor Blood to the Toxic Reaction in Dogs Undergoing Extracorporeal Hemodialysis
FRANK T. MAHER, LEE C. WATKINS, JR., JAMES C. BROADBENT and JESSE L. BOLLMAN

_Circ Res._ 1958;6:47-54
doi: 10.1161/01.RES.6.1.47

_Circulation Research_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1958 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7330. Online ISSN: 1524-4571

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circres.ahajournals.org/content/6/1/47

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in _Circulation Research_ can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to _Circulation Research_ is online at:
http://circres.ahajournals.org/subscriptions/