Comparison of Two Parallel Flow Disposable Artificial Kidneys

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The application of regular haemodialysis in the treatment of patients with chronic renal insufficiency has necessitated a development of effective haemodialysers. In order to safeguard the patient, a small blood volume, low internal resistance and complete drainage at the end of dialysis, together with a stable and uniform function, must be elementary requirements. To the Dialysis Unit staff the disposable kidney is a labour saving device, with which the risk of direct contact with the patient’s blood is greatly reduced.

Below we submit the results of a comparison between two disposable parallel flow artificial kidneys: the Alwall-Gambro Haemodialyser (A-G) (Alwall, 1968) and the Rhône-Poulenc Haemodialyser (R-P) (Funck-Brentano et al, 1969).

MATERIALS AND METHODS

The A-G Haemodialyser is constructed with membranes of Cuprophan PT 300 and has an effective dialysis surface area of 1.02 m² in 11 compartments. The haemodialyser weighs 7.5 kg and measures 59 x 17 x 11 cm. The haemodialyser is held together by metal plates and is sterilized with ethylene oxide. Blood flow resistance is 100 mm Hg at a flow of 200 ml/min (Kulatilake et al, 1969). The blood volume of the haemodialyser, inclusive of blood lines, is approximately 300 ml at a positive blood pressure of 100 mm Hg at the outlet side of the unit.

The R-P haemodialyser has an effective dialysis area of 0.86 m² using Cuprophan PT 150 divided into 8 compartments. The weight is 4.5 kg and it measures 54 x 15 x 5.8 cm. The haemodialyser is made of polystyrene and for use it is secured in a metal holder. Sterilization is by gamma irradiation at 2.5 mega Rad. Resistance to the blood flow was found to be 30 to 35 mm Hg at a flow of 180 ml/min. The blood volume of the haemodialyser, inclusive of blood lines, is just under 300 ml at a positive blood pressure of 100 mm Hg at the outlet side of the unit.
It should be noted that the R-P haemodialyser is constructed in such a way that one or more compartments may be isolated, thus reducing the effective dialysis surface. It can thus be utilised for paediatric haemodialysis or, in the event of membrane rupture, the damaged compartment can be isolated from the remainder of the circuit, thus allowing the patient to continue dialysis without interruption.

We have conducted 50 studies of the A-G Haemodialyser and 75 studies of the R-P Haemodialyser. The same 10 patients were on regular haemodialysis with a fixed fluid intake and diet. They were dialysed for eight hours the same number of times on the two units. During all these dialyses a blood pump was used. For the A-G Unit the blood flow was at an average of 150.5 ml/min and for the R-P Haemodialyser at an average of 134.9 ml/min, measured by means of the air bubble method (Ladehof et al, 1970). The dialysate flow varied from 450 to 800 ml/min with an average of 602 ml/min for the A-G Unit and an average of 632 ml/min for the R-P Unit.

The concentration of urea in the blood and dialysate was measured by means of the Technicon Auto Analyzer method (Technicon, 1963) at a dialysis time of 1, 3, 5 and 7 hours after dialysis had begun. The dialysance was calculated according to the formula:

\[ D = \frac{C_U \times V}{C_A} \]

where \( C_U \) is the urea concentration in the dialysate and \( V \) the dialysate flow measured in ml/min, \( C_A \) is the urea concentration in the arterial blood.

RESULTS AND DISCUSSION

Table I

<table>
<thead>
<tr>
<th>Type of dialyser</th>
<th>Blood flow ml/min</th>
<th>Dialysate flow ml/min</th>
<th>Urea dialysance ml/min</th>
<th>No. of investigations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>A-G</td>
<td>150.5</td>
<td>19.4</td>
<td>602</td>
<td>140</td>
</tr>
<tr>
<td>R-P</td>
<td>134.9</td>
<td>24.4</td>
<td>632</td>
<td>113</td>
</tr>
</tbody>
</table>

As can be seen from Table I, the blood flow in the two types of haemodialyser was very similar. The blood flow was kept constant during each dialysis by means of a blood pump. The effect of the rate of dialysate flow was examined between 450 and 800 ml/min.
In Figure 1 it can be seen that the urea dialysance was greater for the R-P Haemodialyser at all dialysate flows. This was more pronounced at low dialysate flows, but the difference decreased as the dialysate flow approached 800 ml/min. At an average dialysate flow of 602 ml/min with the A-G Haemodialyser, a urea dialysance of 60 ml/min was obtained. At an average flow of 632 ml/min with the R-P Haemodialyser, a dialysance of 86 ml/min was obtained. The urea dialysance was found to be constant for both cells during the dialysis (Kulatilake et al, 1969).

The average loss of weight during a dialysis of 8 hours duration was 2,330 g with the A-G Haemodialyser at an average negative pressure of 130 mm Hg. The R-P Haemodialyser gave a weight loss of 1,410 g on average at a negative pressure of 110 mm Hg. The control of the amount of weight loss by alteration of the negative pressure was trouble-free in both haemodialysers.

The blood leak rate in the A-G Haemodialyser was found to be 0.1% and in the R-P Haemodialyser 2.5%. However, with the R-P Haemodialyser it was not necessary to interrupt the dialysis, since it is possible to identify and isolate the leaking compartment.

The setting up and preparation of the A-G Haemodialyser took an average time of 20 minutes, while the R-P Haemodialyser was ready for use in an average time of 10 minutes. At the end of dialysis the A-G Haemodialyser
was emptied of blood in an average time of 8 minutes, using a saline washback procedure. In the R-P Haemodialysers a gravity return system was used, which gave an average blood restitution time of less than 3 minutes.

In principle the A-G and the R-P Haemodialysers are constructed in the same way. However, the R-P Haemodialysers, with its lower weight, smaller external dimensions and construction of more easily destructible materials, gives greater advantages with regard to transportation, storage and complete incineration. Even though neither of the two sterilization methods employed are perhaps ideal, we have not observed any pyrogenic reactions during our examinations.

Our examinations show that, given constant blood flows, the dialysance is constant in both types of haemodialysers. At a dialysate flow of less than 800 ml/min the R-P Haemodialysers is more effective in terms of urea clearance. This can mean a reduction in cost of sterile water and sterile concentrate supplies which are necessary for optimal haemodialysis treatment (Fregerslev et al, 1971). In addition, the greater dialysance performance of the R-P Haemodialysers allows a shorter time of dialysis for the patient.

With regard to ultrafiltration, the A-G Haemodialysers is more effective and was found to possess an extraordinary stability when subjected to variations of pressure.

REFERENCES


