A NEW DISPOSABLE 150 P.T. CUPRA PHANE TWIN MINICOIL ARTIFICIAL KIDNEY

Queen Elizabeth Hospital, Birmingham, United Kingdom

Development

We believe that ideally the dialyser used in a chronic haemodialysis programme should be compact and disposable. All the assembly should be undertaken in a factory and the unit should be supplied to the hospital sterile, pyrogen free and ready to use. If home dialysis is to become available to as many people as possible this concept is essential. To expect the patient to be capable and willing to accept the task of building and sterilising his or her own dialysers, in addition to running the dialysis, is unreasonable.

Last year we reported the results of a small, chronic haemodialysis programme using two modified Minicoil kidneys connected in parallel (Simpson, Robson, Blainey and Dawson-Edwards, 1965). By enclosing both coils in the same envelope, we were able to develop a very compact disposable unit, the Twin Minicoil, which is commercially available.* It is supplied ready to use so that preparation time is merely the time required to prime it with dialysate and normal saline. These coils have been used in our chronic haemodialysis programme and the details of the four patients receiving regular dialysis are presented in Table I. The clinical results to date which represent fifty patient months’ experience, have been very good.

A new 150 P.T. cupra phane tube has been recently produced by Bemerg and incorporated into the Twin Minicoil, producing a dialyser close to the ideal (Fig. 1). Approximately forty dialyses have been performed using this new coil. It is more efficient than the cellophane coil, as is shown by the results presented here. These coils have been used mainly on patients W.B. and C.R. to date (Fig. 2).

Details of cupra phane coil

The dialysis membrane consists of two ‘lay flat’ tubes of 150 P.T. cupra phane, 5140 mm long and 43 mm wide, having a total surface area of 0.9 sq. metres. The two coils are wound in parallel on a moulded cylinder, the turns being separated by a P.V.C. coated glass filament mesh held apart at the edges by corrugated P.V.C. spacer strips. The twin coil unit is enclosed in a P.V.C. envelope. Two tubes are welded into the envelope for dialysate inflow and outflow. A single pass dialysate flow system at 40°C is used. When in use the envelope must be collapsed by applying negative pressure to the dialysate outflow either by syphon or a pump. The arterial and venous lines complete with pump inserts and bubble trap are sealed into the envelope where they enter and leave the coil. The total volume of the blood circuit is 450-500 ml. For circuit diagram see Fig. 3.

The cellophane Twin Minicoil is the same as this with the exception that a 44 mm ‘lay flat’ tube of viscose cellulose is used.

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age</th>
<th>Diagnosis</th>
<th>Daily urinary volume (ml)</th>
<th>Duration of treatment (months)</th>
<th>Transfusion requirements (units/month)</th>
<th>Average pre-dialysis P.C.V. (%)</th>
<th>General condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>W.B.</td>
<td>M</td>
<td>33</td>
<td>Polycystic kidneys</td>
<td>30</td>
<td>17</td>
<td>0</td>
<td>31</td>
<td>Good</td>
</tr>
<tr>
<td>C.R.</td>
<td>F</td>
<td>27</td>
<td>Chronic pyelonephritis</td>
<td>250</td>
<td>15</td>
<td>3.0</td>
<td>26</td>
<td>Excellent</td>
</tr>
<tr>
<td>R.A.</td>
<td>M</td>
<td>46</td>
<td>Chronic glomerulonephritis</td>
<td>150</td>
<td>11</td>
<td>1.6</td>
<td>27.5</td>
<td>Good</td>
</tr>
<tr>
<td>J.S.</td>
<td>F</td>
<td>44</td>
<td>Acute fulminating glomerulonephritis</td>
<td>Nil</td>
<td>9</td>
<td>3.2</td>
<td>24.5</td>
<td>Fair</td>
</tr>
</tbody>
</table>
Fig. 1. Close-up of new Twin Minicoil in use.

Performance of cuprophane coil

The in vivo clearance curves for urea for the cellophane and cuprophane coils are shown in Fig. 4 and for creatinine in Fig. 5. These are equal to the reported clearances for the two layered Kiil dialyser built with 150 P.T. cuprophane and used with single pass dialysate at 40°C (Murray, Pendras, Lindholm and Erickson, 1964). The improvement of urea, creatinine, uric acid and phosphate extraction by the cuprophane coil is shown in Fig. 6 by expressing the onset level minus the end of dialysis level as a percentage of the onset level after a 14 hour dialysis. These also compare favourably with the results reported for the Kiil dialyser (Fry and Hoover, 1964) but in this reported series the weights of the patients are not quoted and the dialyses more prolonged, so that direct comparison is not possible.

Filtration of water

Water can be removed at the rate of 200 ml/hour with a pressure gradient of 100 mm Hg across the membrane and a dextrose concentration of 200 mg/100 ml in the dialysate. With the cellophane coil, dextrose concentration of 1-2 g/100 ml must be used to remove water during dialysis.
Fig. 2. New Twin Minicoil in use on patient C.R., 14 months after the commencement of regular dialysis treatment.

Fig. 3. New Twin Minicoil dialysis circuit.

Protein leak

In view of the increased permeability of cuprophane, the possibility of a significant protein leak during dialysis was considered. One litre of dialysate was recirculated through the coil for one hour at 500 ml/min. This was collected and concentrated. A small quantity of albumin was detected immunochemically which was equivalent to the loss of 1 mg of protein into the dialysate in one hour, which is negligible.
Fig. 4. In vivo urea clearance curves to show improved efficiency of 150 P.T. cuprophane coil compared with cellophane.

Fig. 5. In vivo creatinine clearance curves to show improved efficiency of 150 P.T. cuprophane coil compared with cellophane.

Inulin permeability

The percentage fall of inulin was 24% for a cellophane coil and 27.5% for a cuprophane
Fig. 6. Improved efficiency of 150 P.T. cuprophane coil compared with standard cellophane illustrated by an increase in the percentage fall of urea, creatinine, uric acid and phosphate during a 14 hour dialysis under comparable conditions, on two patients: W.B. (77 kg) and C.R. (60 kg), during a steady clinical state.

coil, during a 14 hour dialysis. This suggests that there is not an excessive leak of high molecular weight compounds through the cuprophane. Thus it is retaining reasonable selectivity in spite of its increased permeability to small molecules.

Summary

This new cuprophane coil meets many of the ideals for a dialyser suitable for chronic haemodialysis which have already been outlined. It is especially suitable for home dialysis as it is so simple to set up. A patient has been trained for home dialysis using this coil, together with a new proportionating and monitoring unit (Simpson, Blainej, Dawson-Edwards, Hilton, Williams, Cantrill, Manton and Sutherland, 1966).

The only disadvantage of this dialyser at the moment is cost, which is approximately £9 per dialysis. This is justifiable for home dialysis where the saving on running costs of dialysis are considerable compared with hospital dialysis. It is at the moment only produced in small quantities but it will be possible to effect a reduction in cost when larger numbers of coils are used. It is hoped that an improved design being developed will lead to an even further reduction in cost.

ACKNOWLEDGEMENT

One of us, K.M.S., would like to acknowledge the receipt of a full-time grant from the Endowment Fund, United Birmingham Hospitals.

REFERENCES


