The Mini-D, A Versatile Dialyser for Paediatric Dialysis

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The postulates for a safe and effective method of paediatric dialysis (Kjellstrand et al, 1971) require a dialyser in which blood volume and small solute removal may be varied and controlled depending upon the size of the patient. This report demonstrates such a dialyser which we have used safely and effectively in the treatment of 13 patients (over 200 dialyses) weighing between 1.7 and 25 kg with both acute and chronic renal failure.

MATERIAL

Table I summarises the technical information from in vitro and in vivo testing of the variable layer Mini-D. The Mini-D is a non-disposable, multiple point, cone field support parallel flow dialyser* in which the number of parallel layers may be varied between one and eight. The Mini-D was used with one, two, three, four, and five layers depending upon the weight and state of fluid overload of the child. The six, seven, and eight layers are used primarily for the adult patient (Ogden et al, 1971).

<table>
<thead>
<tr>
<th>Dialyser</th>
<th>Membrane</th>
<th>Surface area</th>
<th>Priming volume dialyser</th>
<th>Priming volume blood lines</th>
<th>Compliance</th>
<th>Ultrafiltration</th>
<th>Residual blood loss ***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>cm²</td>
<td>ml</td>
<td>ml</td>
<td>ml/100mm Hg</td>
<td>ml/100mm Hg</td>
<td>ml/layer</td>
</tr>
<tr>
<td>Mini D*</td>
<td>Cuprohane</td>
<td>1240</td>
<td>10</td>
<td>17**</td>
<td>5.6</td>
<td>30</td>
<td>1.8 ± 0.8</td>
</tr>
<tr>
<td>1 layer</td>
<td>PT 150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6200</td>
<td>50</td>
<td>35*</td>
<td>28.0</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Mini D</td>
<td>Cuprohane</td>
<td>6200</td>
<td>50</td>
<td>35*</td>
<td>28.0</td>
<td>150</td>
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</tr>
<tr>
<td>5 layer</td>
<td>PT 150</td>
<td></td>
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</tr>
</tbody>
</table>

* Cobe Laboratories Inc., Denver, Colorado, USA
** AB Gambro, Lund, Sweden
*** Measured after a volume equal to the priming volume of the dialyser plus blood lines had been transfused back into patient

To get data for 2, 3, 4 layer Mini D (surface area, priming volume dialyser, compliance, ultrafiltration) multiply 1 layer data by 2, 3 and 4

* Cobe Laboratories, Denver, Colorado
METHODS

In vitro chloride clearances were done on each number of layers (1-5) to determine the clearance characteristics at low blood flows prior to clinical use. Urea and creatinine were measured in a Technicon Auto-analyser one hour after initiating dialysis. The clearances were calculated according to the formula of Wolff et al (1951). A single pass dialysate system was used in all cases (dialysate flow = blood flow x 4). Priming volume was measured in vitro by filling the dialyser with corn oil, in vivo by filling the dialyser with saline. Compliance was measured by distending the dialysers with corn oil against an occluded venous line in vitro. Ultrafiltration was measured by noting weight loss hourly during dialysis and correcting for intake and output. Residual blood loss was measured using a colorometric method after washout with tap water, volume ten times the dialyser volume. Visual check of the dialyser showed no residual or trapped blood in the dialyser after washout. It must be noted that only the blood priming volume, at 0 mm Hg, contained within the dialyser was transfused back to the patient.

RESULTS AND DISCUSSIONS

We feel that the BUN clearance in millilitres per minute used during dialysis should be between two and three times the patient's body weight in kilograms in order to avoid insufficient or over-aggressive dialysis. We also feel that the dialyser and blood line priming volume should be no more than 10% of the patient's blood volume in order to avoid blood priming and to allow back transfusion. Using these postulates, it has been shown in paediatric dialysis (Kjellstrand et al, 1971; Kjellstrand, 1972) that major complications can be reduced to zero and minor complications to one-third in infants and children or to the same incidence as that for adults. The results of BUN and creatinine

\[ \text{BUN} \quad \text{CREATININE} \]

\[ \begin{align*}
\text{N} &= \text{number of determinations} \\
\text{CL}_{\text{BUN}} \cdot \text{ml/min} & \quad \text{CL}_{\text{Creat}} \cdot \text{ml/min} \\
\text{Blood Flow} \cdot \text{ml/min} & \\
\end{align*} \]

Figure 1. BUN and creatinine clearance versus blood flow. Data obtained one hour after initiating clinical dialysis. Dialysate flow = 4 x blood flow

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clearance are given in Figure 1. The BUN clearance can be varied from zero to a maximum of approximately 20 ml/min for the one-layer at a blood flow of 40 ml/min. The maximum BUN clearance achieved with a blood flow of 100 ml is approximately 70 ml/min with a five-layer Mini-D. When dialysis of a small child is planned, the child's blood volume is calculated based on body weight. The number of layers containing less than 10% of the patient's circulating volume is selected and the blood flow is determined using the BUN clearance versus blood flow graph in Figure 1 to achieve a BUN clearance of two to three times the patient's body weight.

By using different numbers of layers of the Mini-D and different blood lines (13 ml and 35 ml) it is possible to fulfil our postulates when dialysing infants and children of any size over 2.5 kg. In over 200 paediatric dialyses with the Mini-D, 1-5 layers, blood priming was not necessary (except in a premature 1.7 kg infant) and the patients tolerated back transfusion of the blood in the dialyser and blood lines at the end of dialysis. Blood pumps were used in all dialyses for satisfactory perfusion and also to control the rate of clearance.

![Graph showing ultrafiltration rates vs transmembrane pressure](image)

Figure 2. Average ultrafiltration rates, obtained during clinical dialyses

Ultrafiltration is shown in Figure 2. Approximately 30 g/hr/layer of fluid can be removed for each 100 mm of transmembrane pressure. There was one membrane rupture in 200 dialyses. This range of patient use of the Mini-D 1-5 layer is limited by two factors: (1) the lower limit is controlled by the priming volume of the dialyser; (2) the upper limit is controlled by the rate of small solute clearance or dialyser efficiency and by ultrafiltration.

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Figure 3. Range of patient use of the Mini-D 1-5 layers. Lower weight range set by volume of dialyser + blood lines. This volume should be less than 10% of patient's blood volume. Upper weight range set by maximum BUN clearance at reasonable blood flow. BUN clearance should be at least 2 x patient's body weight.

capabilities. Figure 3 illustrates the range of patient use of the Mini-D 1, 2, 3, 4 and 5 layer applying these two factors, dialyser priming volume not more than 10% of the patient's circulating blood volume, and dialyser efficiency (BUN clearance ml/min = 2 x body weight in kilograms).

SUMMARY

The Mini-D is a versatile dialyser very suitable for paediatric haemodialysis. By varying the number of layers used, the correct size and blood flow can be prescribed for any child weighing 2.5 kg or more. Using simple postulates of dialyser volume and dialyser efficiency based on the patient's body weight, major complications can be avoided and minor complications will not occur more frequently even in infant haemodialysis than they occur in adult dialysis.

REFERENCES