Part I

TECHNICAL ASPECTS OF MACHINES

Chairman: Dr. B. Watschinger
A Disposable Parallel Flow Artificial Kidney

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Since 1956, at Hammersmith Hospital, we have haemodialyzed 610 patients for renal failure. During the period 1956 to 1969 the Rotating Coil type artificial kidney was used for five years, the disposable twin coil type for another five years and the modified Kiil machine since 1964. Seventy-six patients have been treated in the long term intermittent haemodialysis programme since it was started in August 1963. This gives a total experience of 666 patient months. One patient was on the programme for 63 months. Four patients died while still on the programme, but only one due to a complication of dialysis. This death was after replacement of the mitral valve when it became incompetent due to septic vegetations following septicaemia. At the time of operation the vegetations were found to be sterile. There were 6 other cases of septicaemia successfully treated with antibiotics.

The average haemodialyses per year in the last three years was 2569. It was with this experience of haemodialysis that the disposable, low resistance, efficient dialyzer that could be operated without a blood pump described to this association in 1968 (Alwall, 1968) was tested in our Unit. We compared the performance of this dialyzer with that of the modified Kiil dialyzer that is used in our Unit. Having compared these two dialyzers we assessed a smaller 6 layered (or paediatric) version of this machine. The performance of the 6 layered dialyzer was not compared with that of the Kiil machine.

MATERIALS AND METHODS

All the patients selected for this study were in a steady state as regards weight, blood pressure and blood electrolytes. They had been on twice weekly dialyses of 12 hours each for at least three months on the Kiil machine without blood pumps. Dialysis fluid was delivered and monitored by individual units at a flow rate of 500 ml/min and 38°C. There was no recirculation. The blood pressure, the venous pressure, dialysate negative pressure and the
patients' weights were monitored hourly. Blood flow through the dialyzer was measured hourly by the bubble method and an ultrasonic method.

(a) In comparing the efficiency of the Kiil with that of the adult type of disposable dialyzer (11 layers), 11 patients were dialyzed alternately on the two machines.

(b) The 6 layered disposable dialyzer was tested on 6 patients on alternate weeks.

The regression lines passing through zero in Figures 4, 5 and 6 were calculated by the method of least mean squares, since the relationship of dialysis to flow rate appeared to be roughly linear over the range of observations.

RESULTS

1. BLOOD FLOW
The mean blood flow rates through the three types of dialyzers are shown in Table I.

<table>
<thead>
<tr>
<th>TABLE I. Blood Flow Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Blood Flow (ml/min)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hours of Dialysis</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiil Dialyzer</td>
<td>95.2</td>
<td>120.5</td>
<td>95.2</td>
<td>97.9</td>
<td>87.0</td>
<td>84.5</td>
</tr>
<tr>
<td>A.G. (11 layers)</td>
<td>71.4</td>
<td>101.2</td>
<td>113.2</td>
<td>100.7</td>
<td>98.9</td>
<td>102.0</td>
</tr>
<tr>
<td>A.G. (6 layers)</td>
<td>124.1</td>
<td>115.8</td>
<td>117.8</td>
<td>107.8</td>
<td>102.3</td>
<td>111.9</td>
</tr>
</tbody>
</table>

A.G. (11 layers) = Ab Gambro 11 layered (Adult) Dialyzer;
A.G. (6 layers)   = Ab Gambro 6 layered (Paediatric) Dialyzer

![Figure 1. The creatinine dialysance (ml/min) as dialysis progressed in time (hr)](image-url)
2. (a) COMPARISON OF KIIL AND 11 LAYERED DIALYZER
(i) Creatinine dialysance vs. Time
Figure 1 shows the mean (and the standard errors of the mean) of the creatinine dialysance in the two dialyzers as the dialysis progressed. The performance of the disposable dialyzers was better and the values were statistically significant.

![Figure 1](image1)

Figure 2. The urea dialysance (ml/min) as dialysis progressed in time (hr)

Ab Gambro (Pediatric D.)

![Figure 2](image2)

Figure 3. The creatinine and urea dialysance as dialysis progressed in time in 6 layered A.G.
(ii) Urea dialysance vs. Time
Figure 2 shows the mean of the urea dialysance in the two dialyzers as the dialysis progressed. The performance of the disposable dialyzer was better and the differences were statistically significant.

(b) 6 LAYERED DISPOSABLE DIALYZER
Creatinine and urea dialysance vs. time
Figure 3 shows the mean (and the standard error of the mean) of the dialysances as the dialysis progressed.

3. CREATININE DIALYSANCE vs. BLOOD FLOW
(a) Figures 4 and 5 show the results for the Kiil and the 11 layered disposable dialyzer. The 11 layered disposable dialyser had a better clearance for the same blood flow rate at and above 100 ml/min.
(b) The corresponding results for the 6 layered disposable dialyzer are shown in Figure 6.

![Figure 4. The relationship between creatinine dialysance and blood flow in Kiil](image)

4. WEIGHT LOSS AND DIALYSATE NEGATIVE PRESSURE
(a) The mean weight loss on the Kiil was 193 gm/hr for a mean negative pressure of 54 mm Hg (Papadimitriou & Kulatlake, 1969), while the respective values for the 11 layered disposable dialyzer were 190 and 79.
(b) The required weight loss and what was achieved at the negative pressure used in the 6 layered disposable dialyzer are as shown in Table II.
Figure 5. The relationship between creatinine dialysance and blood flow in A.G. 11 layered dialyzer.

Figure 6. The relationship between creatinine dialysance and blood flow in the A.G. 6 layered dialyzer.
TABLE II. The weight loss achieved in the 6 layered dialyzer

<table>
<thead>
<tr>
<th>Number of dialyses</th>
<th>Mean weight loss required</th>
<th>Mean weight loss achieved</th>
<th>Mean negative pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>2.0 kg</td>
<td>1.1 kg</td>
<td>109 mm Hg</td>
</tr>
<tr>
<td>6</td>
<td>2.1 kg</td>
<td>1.7 kg</td>
<td>199 mm Hg</td>
</tr>
</tbody>
</table>

DISCUSSION

The blood flow rate through a Kiil is variable, but at the beginning of dialysis it appeared to be better than that in the 11 layered disposable dialyzer, but towards the latter part of the dialysis the disposable dialyzer had better flows, which was possibly due to the higher negative pressure used in the machine.

Even though the dialysis membrane surface area of the Kiil and the 11 layered disposable dialyzer were comparable, it is likely that the construction of the latter allows more effective dialysis area and hence a better dialysance for creatinine and urea as observed in the latter part of the dialysis. Also the fact that towards the latter part of dialysis there is an increase in blood flow must improve the dialysance in the disposable dialyzer. The clearances of the 6 layered disposable dialyzer were not comparable with those results obtained by us for the Kiil, but they appear to compare favourably with those of others (Freeman et al, 1964). Even though we had hoped that a 6 layered disposable dialyzer would be sufficient for twice weekly 12 hour dialyses for our patients, we feel that the clearances were not sufficient to justify their use in this manner. However, we feel that this machine could be suitable for thrice weekly dialyses.

In the disposable dialyzers the dialysis membrane is Cuprophan PT300 and hence higher dialysate negative pressure is essential to obtain comparable ultrafiltration to that produced by the Kiil in which Cuprophan PT150 is normally used. On the other hand, a certain number of membrane ruptures is usual in the Kiil, but not in the disposable dialyzer. Of the 140 disposable dialyzers we have so far used we have not seen any ruptures. We feel that these disposable dialyzers would give satisfaction to the home dialysis patient even as a standby for the Kiil. We ourselves use these as standby for weekend dialysis and they are routinely used for infected patients. There are advantages in using similar equipment in both an 'acute' and 'chronic' dialysis unit and we ourselves prefer to use the Disposable system, as the medical and nursing staff have better experience in the use of these dialyzers. The use of a blood pump in the 11 layered disposable dialyzer has allowed a reduction of dialysis time (Alwall, 1969). Hence a hypercatabolic patient can be
adequately dialyzed as high blood flow rates can be achieved.

The advantages in the use of disposable apparatus in long term dialysis need no discussion. We can justify the use of these dialyzers in this context. It is well known that infection is a common complication of long-term haemodialysis.

The only disadvantage in using these disposable dialyzers appears to be their cost. But we are assured that if more dialysis centres were to use them their price could be reduced to more practical figures.

CONCLUSIONS

The 11 layered disposable dialyzer has all the advantages of a Kiil machine and in fact has better dialysances for urea and creatinine. These can be used instead of Kiil dialyzers with existing dialysate delivery systems. The 11 layered dialyzer is satisfactory for home dialysis and also for patients with acute renal failure. The 6 layered disposable dialyzer is only satisfactory for thrice weekly maintenance dialysis.

REFERENCES

Alwall, N. (1969) Personal communication