THE CHRONACOIL

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A disposable dialyser for intermittent dialysis would be a major advance. The Chronacoil has been developed from the original Kolff-Watschinger twin coil to meet this requirement. It has a similar twin coil arrangement but each coil is only 5.2 m in length, giving a surface area of approximately 0.9 sq.m. The central core has been widened so that the shorter coil has the same diameter as the original twin coil and can therefore be used in the holding can of the standard Travenol kidney. The core is now moulded in one piece, which reduces the leakage of dialysis fluid up the centre.

A dialyser for chronic renal failure should be easy to assemble and thoroughly reliable, to inspire patient confidence. It should have a low priming volume that does not alter drastically with changing blood flow and pressure and it should be possible to displace nearly all its blood content back into the patient. It should have a reasonable dialysance and rate of ultrafiltration. It should have a low resistance to blood flow, permitting dialysis without blood pump if possible, and it should be of low cost. We have studied the Chronacoil from these points of view during 50 dialyses for chronic renal failure at Newcastle and 20 for acute renal failure at Halton.

Reliability and ease of handling
The Chronacoil has the same ease of handling and freedom from breakdown as the original twin coil. It can be assembled in a few minutes by nursing and technical staff after minimal training and is undoubtedly more popular with them and with patients than the Kiil dialyser.

Priming volume
During 15 dialyses at Halton the coil was primed with blood. Blood reached the venous end of the circuit after approximately 450 ml had been run in; of this, 150 ml are accounted for by the arterial and venous circuits.

The static coil+circuit volume was measured in vitro during 4 experiments in Newcastle. The mean volume on 2 new coils was 440 ml, on 2 used coils 525 ml.

It would appear that the coil without circuit holds about 300 ml blood at the beginning of dialysis and about 375 at the end. This is little higher than the Kiil, in our experience.

During 50 dialyses at Newcastle (including 20 on 2 children aged 13) the coil was used without priming blood and hypotension was not a significant problem.

Change in coil volume
In all dialysers the blood content under running conditions is appreciably higher than the static volume. The ‘blood uptake’ by the dialyser is related to the mean pressure \[\frac{1}{4}(\text{inflow pressure} + \text{outflow pressure})\] and at low pressures the relationship is usually linear. The blood uptake of the Chronacoil was studied in 4 coils in vitro and mean results are shown in
Figure 1. The uptake bears an almost linear relationship to mean pressure to about 150 mm Hg. Thereafter expansion occurs more slowly as the coil nears its elastic limit.

\[ \text{CHRONACOIL BLOOD UPTAKE AGAINST MEAN PRESSURE} \]

![Graph showing CHRONACOIL BLOOD UPTAKE AGAINST MEAN PRESSURE](image)

Fig. 1. Relationship between blood uptake by the coil and mean pressure in the blood pathway.

A rough estimate of mean pressure in the coil can be made from the blood flow rate and outflow (‘venous’) pressure. The difference between inflow and outflow pressure at different flow rates is shown in Figure 2 (mean of 4 coils perfused in vitro with blood of haematocrit about 30%). Under normal dialysing conditions—blood flow 300 ml/min and outflow pressure 50 mm Hg—the average uptake of the coil is about 270 ml, bringing its total volume to 550–600 ml.

Return of blood to the patient

Blood is usually returned to the patient by washing through the coil with saline. After the saline had been given we disconnected the coil on 4 occasions and recirculated a known volume of saline through it repeatedly. The residual volume of blood in the coil was calculated from the RBC count in the patient’s blood and the coil washing.

<table>
<thead>
<tr>
<th>Volume of saline given (ml)</th>
<th>Residual blood volume (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>11</td>
</tr>
<tr>
<td>750 (mean of 3)</td>
<td>35</td>
</tr>
</tbody>
</table>

Since 35 ml is near the maximum blood loss into the coil which can be permitted on a long term basis for intermittent dialysis, we have not tried smaller wash-through volumes. When it is important to avoid giving extra saline, the blood can be returned to the patient by stripping and milking the coil. The arterial circuit is drained into the coil which is then
THE CHRONACOIL
dismantled and stretched over a beam. Blood is drained along the tubing by gravity assisted by manual compression through the fibreglass supporting screen.

\[
\frac{\text{Residual volume after 'milking'}}{\text{(mean of 5 coils)}} = 28 \text{ ml}
\]

‘Milking’ takes only about 10 minutes and we have adopted it as our standard method of returning blood to hypertensive patients.

![Graph](image)

*Fig. 2. Relationship between pressure drop across the coil and blood flow rate.*

*Resistance to blood flow*

Figure 2 was constructed from 4 experiments with blood of ‘uraemic’ haematocrit—approximately 30%. It is clear that a pressure well above normal systolic would be required to drive blood through the coil at high flow rate. In practice the blood flow under arterial pressure alone was usually 50–70 ml/min. The Chronacoil is therefore unsuitable for pumpless dialysis. Since we normally use a blood pump even with the Kiil at Newcastle, we are not unduly perturbed by this defect in the Chronacoil.

*Ultrafiltration*

It can be assumed that the ultrafiltration rate for a given pressure in the Chronacoil is about half that with the large twin coil (for data on large twin coil see Adjei *et al.*, 1964a). Under standard dialysing conditions of 300 ml/min flow rate and 50 mm Hg return pressure the expected ultrafiltration rate is about 2.5 ml/min.

During 15 dialyses of 6–8 hours at Halton, without constriction of the venous line, weight change varied from +0.75 kg to −1.75 kg (mean −0.80 kg). With constriction of the outflow to raise coil pressure, up to 2.35 kg were removed during 6 hours.

The Chronacoil has adequate capacity for ultrafiltration except in dealing with grossly overhydrated patients, when a larger dialyser is more suitable.
Dialysance

In vivo dialysance measurements were made by standard techniques during 25 ‘chronic’ dialyses at Newcastle and 10 ‘acute’ dialyses at Halton. The Newcastle observations were made with the coil sealed in a polythene bag to limit leakage of dialysis fluid; at Halton a plastic ring was used to seal the coil in the usual holding can. Results are shown in Table I and Figure 3.

Fig. 3. Urea, creatinine and urate dialysance at varying blood flow rate on Chronacoil.

The Chronacoil is slightly more efficient, size for size, than the large twin coil. The mean Newcastle figure for urea dialysance at 300 ml/min is 107 ml/min, which corresponds to 178 ml/min for a full twin coil. This is a little higher than the 163 ml/min found by Adjei et al. (1964b) with the twin coil studied by the same techniques.

| TABLE 1 |
| Dialysance of urea, creatinine and urate with Chronacoil |
| No. of coils | No. of observations | Dialysance at blood flow of: (ml/min) |
| Urea | N* | 25 | 93 | 57 | 87 | 107 | 118 |
| | H** | 11 | 83 | 101 | |
| Creat. | N* | 25 | 94 | 46 | 65 | 79 | 87 |
| | H** | 11 | 91 | 71 | |
| Urate | N* | 25 | 94 | 38 | 52 | 60 | 65 |

N* = Newcastle results  
H** = Halton results
THE CHRONACOIL

The fall in blood urea etc. during dialysis depends on many factors apart from dialysance, but in a large series it gives a rough guide to dialyser efficiency. The results in Table II were obtained during 18 dialyses of 12 hours in adults and 4 of 8 hours in children with chronic renal failure (Newcastle) and 13 dialyses of 6 hours in adults with acute renal failure (Halton). They are similar to the results we obtain with the Kiil in the same circumstances.

**TABLE II**

*Fall in plasma urea, creatinine and urate levels during dialysis with Chronacoi (expressed as a percentage of predialysis level)*

<table>
<thead>
<tr>
<th></th>
<th>Acute dialysis (Halton)</th>
<th>Chronic dialysis (Newcastle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of coils</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>Duration of dialysis (hours)</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Blood flow rate (ml/min)</td>
<td>280–350*</td>
<td>200–300**</td>
</tr>
<tr>
<td>Fall in plasma urea</td>
<td>50%</td>
<td>67%</td>
</tr>
<tr>
<td>Fall in plasma creat.</td>
<td>40%</td>
<td>56%</td>
</tr>
<tr>
<td>Fall in plasma urate</td>
<td>—</td>
<td>60%</td>
</tr>
</tbody>
</table>

* Flow rate monitored continuously through dialysis.
** Approximate values—flow rate monitored for part of dialysis.

Cost

We believe that the right place to construct artificial kidney circuits is the factory, not the hospital. Disposable units will almost certainly prove more economical than site-built kidneys eventually. At the moment costing is largely speculative but on our calculations it may prove more economical to use Chronacoiis than, for instance, Kiils in units handling up to 3 or 4 patients on twice weekly intermittent dialysis, because of savings in technicians' salaries.

Role of the Chronacoi

*Acute renal failure and transplant.* The larger dialysers such as the original twin coil will probably remain first choice for most patients with acute renal failure but the Chronacoi should find an application (a) in paediatrics; (b) where priming blood is scarce or is contraindicated—underdeveloped countries, after transfusion reactions, or during preparation for renal transplantation; (c) to limit blood requirements during daily dialysis for hypercatabolic renal failure (after initial treatment with larger dialyser).

*Chronic renal failure.* The above suggestions about its use in long term dialysis are based on the assumption that the Chronacoi will prove as effective in maintaining long term health as the Kiil. This remains to be proved and some long term studies should be set up. The Cuprophan usually employed with the Kiil has been said to allow the passage of larger molecular weight uraemic toxins (unidentified) more easily than the standard PT 300 cellophane of the coil dialysers. This suggestion is not amenable to proof or disproof; certainly the identifiable metabolic products up to the molecular weight of urate pass satisfactorily through the Chronacoi.

The introduction of the Chronacoi in USA last year was followed by a wave of misdirected enthusiasm for short dialysis in chronic renal failure. If the Chronacoi is to be assessed fairly, it must be used for about 12 hours twice weekly in the same manner as the Kiil.

REFERENCES
