ONE CANNULA HAEMODIALYSIS

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PRINCIPLE

If one obtains (temporary or permanent) access to one large vein (e.g. the inferior vena cava) by a cannula of sufficient calibre, one can alternatively suck blood of the patient into the dialyser and pump the same blood volume back from the dialyser into the patient.

We chose a phase reversal time of 7.5 seconds. In this time 50-60 ml. blood is sucked from, and pumped back into, the patient.

In Figure 1, Diagram 2 the technical principle concerning blood flow between cannula and dialyser is depicted. Two lines (of silicone rubber-tubing, inside diameter 5 mm.) run from the end of the caval cannula to the entry and the exit of the dialyser respectively. A roller pump was put on each line pumping in opposite directions. The tubing is clamped at A and B alternatively and thus reversal of flow direction is obtained in the cannula. Only the small volume of blood in the cannula and connecting piece is re-circulated (5 ml.). In earlier experiments we put the roller pump on a tube, shunted between the two lines. Reversal of flow direction was obtained by alternately compressing the tubes at point A and D and point C and B. In this setup the rather large volume of the pump tubing (40 ml.) was re-circulated and thus clearance lessened (Figure 1, Diagram 1).

The inflow and outflow tubes are shunted near the dialyser (Figure 2) and to this shunt a calibrated reservoir is attached, by which the apparatus is primed with donor blood. Before dialysis, flow rate is checked by way of the shunt and the calibrated reservoir, as the rise and fall of the blood column in the reservoir indicates the volume of blood displaced in each phase.

A manometer is attached to the entry and to the exit of the dialyser. The pressure indicated by the entry manometer has a linear correlation with the perfusion rate.

The silicone-rubber tubing is compressed by a blunt metal knife (Figure 2 K) which clamps always one tube, leaving the other tube free. The knife is powered by compressed air (± 1 atmosphere). The two and fro movement is obtained by air pressure on a knife-carrying piston in a perspex cylinder with two chambers, one on the right and one on the left side of the piston (see insert Figure 2).

The alternating air pressure and air release in the two chambers is obtained by three electrically monitored valves, one for directing the pressure to either the right or the left chamber and two for alternately releasing the air out of each chamber. This mechanism is controlled by a time clock which allows phases of 7.5, 10 and 15 seconds or longer (Figure 3).

The roller pump used is the springloaded roller pump described in the 1961 issue of the Journal of the American Society of Artificial Internal Organs (Figure 4)(1). Flow rates (total) up to 600 ml./min. are obtained even with a cannula of slightly less than 3 mm. inside diameter. We used the same (thinwalled) teflon tubing (size 10), which is used in the 'Scribner' shunt. The length of the cannula is approximately 25 cm. and the end is

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tapered to facilitate introduction in the inferior caval vein by way of the saphenous vein. For repeated use this cannula is usually introduced by the Seldinger technique(2). Three rather large side-openings ensure optimal flow rate. The advantage of the introduction of one small calibre (3 mm.) cannula instead of two cannulas of 2 mm. or of one cannula of 6 mm. (2 channel cannula) is obvious.

CLINICAL EXPERIENCE

Up till now 32 haemodialyses of 4-6 hours have been performed with satisfactory results. Urea clearances of 60-130 ml./min. have been obtained (depending on the surface area used) and no harmful consequences for the patient have been observed.

We used a modified Alwall type kidney with a capacity of either 12, 18 or 24 m. of cellophane tubing.

In the following table mean clearances are depicted. Clearance in the 24 m. kidney was less than in the 18 m. as perfusion rate was considerably lower on account of increased resistance.

<table>
<thead>
<tr>
<th>Capacity of dialyser in m. cellophane</th>
<th>Number of dialyses</th>
<th>Perfusion rate in ml./min.</th>
<th>Average C urea in ml./min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>17</td>
<td>100-150</td>
<td>65</td>
</tr>
<tr>
<td>18</td>
<td>11</td>
<td>200-240</td>
<td>78</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>200-240</td>
<td>68</td>
</tr>
</tbody>
</table>

Table I. Perfusion rate and average urea clearance in 32 haemodialyses.

In the beginning we sometimes found a tendency to hypotension which was promptly relieved by blood transfusion. This hypotension was accompanied by an increase in pressure in the extracorporeal circuit, indicating a movement of blood from the intracorporeal to the extracorporeal space. This can be explained by the fact that suction of blood out of the patient is easier than suction of blood out of the dialyser. After a certain time equilibrium occurs. A dialyser with a fixed extracorporeal volume is essential.

REFERENCES

Figure 1. Two possibilities of tube connections between cannula and haemodialysator.

Figure 2. Diagram of tube connections employed in one cannula haemodialysis.
K = Knife. RP = Roller pump. CH = Chamber. P = Piston.
Insert: Knife-bearing piston and two air chambers.

Figure 3. Schematic drawing of electrical circuit and valves.

Figure 4. Roller pump without tubes.
Mounted on the pump the air powered clamping knife.
N. SLADE (Bristol): We have been using a single-cannula technique for about a year. It is single-cannula in rather a different sense in that the main cannula, which is introduced via the long saphenous into the femoral vein is T-shaped and large size, and a smaller cannula is inserted through the main branch and goes up a further distance into the inferior vena cava (Figure 1 & 2). During dialysis the in-flow to the patient is through the main branch via the smaller cannula and the take-off is through the side arm, the smaller cannula being a loose fit within the bigger cannula. This involves a single cut-down on the long saphenous vein, and we have been able to do multiple dialyses through this over a period of days. Between dialyses the smaller cannula is removed and the larger cannula is kept open by a slow heparinised drip.

Our flow rate and clearance is not quite as efficient as in an orthodox method, but it is significant that since using this method we have had no trouble with dialysis disequilibrium.

Figure 1. Inner and outer cannulae shown separately.
S.T. BOEN (Seattle): I should like to ask Dr. Twiss whether he empties the kidney during the 7½ seconds when the blood is sucked out of the kidney. What is the volume of the kidney itself?

E.E. TWISS (Rotterdam): The volume of the kidney is, as you know, rather large in our 18-metre kidney. Perhaps Dr. Alwall has a better volume, but we have a volume of about 1 litre. The volume of blood displaced in each phase is about 50 ml. or a maximum of 75 ml. I think the maximum displaced volume should not exceed one-tenth of the total volume.

D.N.S. KERR (Newcastle upon Tyne): Dr. Twiss said that a dialyzer of fixed volume was necessary, but even the Alwall kidney has a variation of several hundred ml. between maximum and minimum. How much extra volume do you push into a dialyzer before you reach this equilibrium stage?

E.E. TWISS (Rotterdam): I think that an absolutely fixed extracorporeal volume is not possible. We have a variation of about 10 per cent of the volume, and if you have a kidney like this you can use this technique, I think. For very low volume kidneys this technique would probably be tiresome, as I said in correspondence with Dr. Kolff once. He suggested that we should put behind the dialyzer a sort of reservoir to catch the pressure. I think that some such solution as this is possible.

THE CHAIRMAN, (F.M. PARSONS (Leeds): There are many instances when it is difficult to gain access to the vascular bed - for example, severe burns. Have you ever thought of using the superior vena cava as well as the inferior vena cava?

E.E. TWISS (Rotterdam): Not yet, because the Seldinger technique is generally so easy in the inguinal region.