DIALYSIS FLUID REQUIREMENTS FOR MINGLE PASS DIALYSIS WITH COIL DIALYSER

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'Mingle pass' is a colloquialism suggested by Dr. T. Garrett to describe continuous replacement of a small reservoir of fluid for recirculation dialysis ('Single pass with recirculation'). The system has been described in principle by Michielsen (1965) and is in use in various forms in many centers, particularly in the U.S.A. The inexpensive apparatus used in Newcastle (now available commercially*) is shown diagrammatically in Figure 1; the principle is the same as in Michielsen's version except that dialysate is added to the can directly rather than into the inflow tube to the pump. At clinically important flows (dialysate addition less than 1 litre per minute, pump speed about 30 litres per minute) this makes a negligible difference to the efficiency of the apparatus.

![Diagram of mingle pass system](image)

Mingle-pass systems are used in two main situations: (1) at dialysis stations supplied from a central tank or proportioning system; here the only limitation on dialysis fluid supply rate is cost or machine capacity; (2) in home dialysis units supplied from a small tank; here the supply rate is limited by the size of the tank and the length of dialysis.

We deal here only with the first situation. The much more complicated mathematics of tank-mingle-pass dialysis will be dealt with elsewhere (Kennedy and Kerr, 1967).

**Theory**

The simplest system to study theoretically is an in vitro experiment in which blood is pumped from a large reservoir through the coil to waste so that inflow concentration of urea (or other test substance) is constant. From the start of dialysis the urea level in the reservoir rises till it reaches equilibrium. The urea inflow rate from the coil to reservoir must then equal the outflow rate in dialysate running to waste.

\[
\begin{align*}
  f & \text{ dialysis fluid inflow} = \text{dialysis fluid outflow (ml/min)} \\
  b & \text{ bath fluid urea level (mgm\%)} \\
  F & \text{ blood flow rate (ml/min)} \\
  A & \text{ blood urea level in inflow (mgm\%)} \\
  V & \text{ blood urea level in outflow (mgm\%)} \\
  C & \text{ urea clearance of coil at blood flow } F \text{ (ml/min)} \\
  D & \text{ urea dialysance of coil at blood flow } F \text{ (ml/min)}.
\end{align*}
\]

By definition \( C = \frac{F(A - V)}{A} \) and \( D = \frac{F(A - V)}{A - b} \)

\[
C = \frac{D(A - b)}{A}
\]

Equation (1)

Under equilibrium conditions:

\[
f \cdot b = C \cdot A = D \cdot \frac{(A - b)}{A} \cdot A = D(A - b)
\]

Substituting for \( C \) from (1)

\[
b = \frac{D \cdot A}{D + f}
\]

Equation (2)

If dialysis fluid pump speed and blood flow remain constant dialysance will not alter and bath water urea level (\( b \)) and the urea clearance of the coil (\( C \)) will be determined only by the supply rate of dialysis fluid (\( f \)) and will be independent of the size of the reservoir.

Using formulae (1) and (2) one can calculate for each chosen dialysis fluid flow rate the bath water urea level, the urea clearance and the clearance as a percentage of dialysance (a measure of how nearly running conditions approximate to the perfect circumstances of single pass at full pump speed).

**Results**

The results for coils of dialysance 100 and 150 ml per minute (corresponding to chronacoil and Twin Coil at blood flow of about 250-300 ml per minute) are shown in Figures 2 and 3. Comparison with the curve for the twin coil in single pass (Adjei et al., 1964) shows that mingle pass is more efficient at low and medium supply rates (the clinically important ones) presumably because a fairly fast flow of dialysis fluid over the coil is necessary to produce turbulence. At very high rates single pass is superior.
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![Graph](image)

**Fig. 2.** Urea clearance as a function of dialysis fluid supply rate (blood flow constant).

![Graph](image)

**Fig. 3.** Urea clearance as a percentage of dialysance related to dialysis fluid supply rate.

### Discussion

These results are applicable to the circumstances of in vivo dialysis only if the reservoir is small so that the turnover time of its contents is low in relation to the length of dialysis. The error due to a falling urea level in inflowing blood is then small. This is true of our own system and Michielsen’s where reservoir volume, including coil deadspace is 4-6 litres, and Michielsen’s (1965) experimental data correspond closely to the theoretical result.

The supply rate selected in practice will depend on the relative cost of dialysis fluid, coils and staff time as well as the dialysance of the coil. In Newcastle dialysis fluid is much the least expensive commodity and we aim at a urea clearance of about 85% of dialysance.
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(Figure 3). This calls for about 550 ml/min for a chronacoil and 850 ml/min for a twin coil. Where dialysis fluid is more expensive, as in many centres in the U.S.A., it may be better to aim at a clearance of only 80% of dialysance.

REFERENCES

EDTA Proceedings 1, 307.