Distortion of Dialysance by Ultrafiltration, and its Correction by Means of a Simple Method

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Fluid loss from the blood passing a dialyser distorts the dialysance of dialysable solutes (Kramer et al., 1969) commonly calculated from the decrease of plasma concentration during the passage \((c_{bi} - c_{bo})\) multiplied by the blood flow rate at the inlet of the dialyser \((Q_{bi})\) and divided by the concentration gradient between the 'inlet blood' \((c_{bi})\) and the rinsing fluid \((c_{u})\) (Wolf et al., 1951). The concentration of the solutes in the returning blood \((c_{bo})\) is relatively too high if water is ultrafiltered in the dialyser (Barenberg & Kiley, 1961). This error is of particular importance, when dialysers with high and low fluid loss by ultrafiltration have to be compared. Fluid loss by ultrafiltration \((U_f)\) is given by the difference between the blood flow rate at the inlet and the outlet of the dialyser
\[
(1) \quad U_f = Q_{bi} - Q_{bo}
\]
and dialysance corrected for ultrafiltration \((D_{uf})\) is given by
\[
(2) \quad D_{uf} = \frac{(Q_{bi} \cdot c_{bi}) - (Q_{bo} \cdot c_{bo})}{c_{bi} - c_{u}}
\]
However, the determination of the ultrafiltration rate and the corrected dialysance by means of formulae (1) and (2) is limited because of the inaccuracy in measuring the blood flow rate. In our experience the coefficient of variation of the bubble flow method is 5%. This variability produces a coefficient of variation of 100% for the determination of the ultrafiltration rate. This error may be reduced to less than 20% by using concentration changes of non-dialysable solutes \((c_{bi}^h \rightarrow c_{bo}^h)\) as a parameter for fluid loss.

The amount of non-dialysable solutes entering and leaving the dialyser per time unit is equal.
\[
(3) \quad Q_{bi} \cdot c_{bi}^h = Q_{bo} \cdot c_{bo}^h
\]
From equation (1) and (3) follows
\[
(4) \quad U_f = Q_{bi} \left[ 1 - \frac{c_{bi}^h}{c_{bo}^h} \right]
\]
and from equation (2) and (3) the corrected dialysance may be derived as

\[
D_{uf} = Q_{bi} \left[ \frac{c_{bi}^h - c_{bo}^h}{c_{bi} - c_{bo}} \right]
\]

Using the increase of total blood haemoglobin concentration as a parameter for fluid loss, the ultrafiltration rate and the corrected dialysance were determined at increasing blood flow rates in four different dialysers: Rhône Poulenc B flatbed (0.88 m²), AB Gambro flatbed (1.2 m²), Medix-SP-75-coil (1.05 m²) and Kiil flatbed with collagen membranes (0.45 m²). Total blood haemoglobin was determined by transforming haemoglobin to cyanohaemoglobin (100 μl of blood were added to 20 ml of a solution containing 1.0 g NaHCO₃, 0.2g K₃Fe(CN)₆ and 0.05 g KCN per litre of distilled water) and measuring the extinction of the red-coloured solution at a wave length of 546 nm (Betke & Savelsberg, 1950). The coefficient of variation of the haemoglobin determination was reduced to less than 0.5% by 4 determinations per blood sample.

![Ultrafiltration rate in various dialysers at increasing blood flow rates](image)

Figure 1. Ultrafiltration rate in various dialysers at increasing blood flow rates
(mean values ± s.e., n = 10)

Figure 1 represents the fluid loss by ultrafiltration at increasing blood flow rates and at a pressure gradient of 100 mm Hg from blood to rinsing fluid at the blood outlet of the dialyser. High fluid loss was measured in the Medix-SP-75-coil and the Kiil dialyser with collagen membranes.

Figures 2 and 3 demonstrate the corrected urea and creatinine dialysance of the above dialysers at increasing blood flow rates. The uncorrected dialysance is indicated by the interrupted lines. (The regression curves are calculated by the method of least squares transforming the values of the blood
Figure 3. Dialysance of urea at increasing blood flow rates in various dialysers
(mean values of the corrected dialysance ± s.d., n = 10)

Figure 3. Dialysance of creatinine at increasing blood flow rates in various dialysers
(mean values of the corrected dialysance ± s.d., n = 10)

Flow rate into logarithms.) As shown in the figures, fluid loss by ultrafiltration causes a considerable distortion of dialysance in the Medix-SP-75-coil and the Kiil collagen plate. This distortion therefore has to be taken into consideration when comparing dialysers with high and low fluid loss by ultrafiltration. A comparison of Figures 2 and 3 reveals that the distortion of dialysance is more prominent with creatinine, the molecular weight of which is almost twice that of urea. This finding is explained by the relation

(6) \[ D_{uf} = D + Uf \frac{c_{bo}}{c_{bi} - c_{u}} \]

The distortion of dialysance is inversely related to the decrease of the con-
centration of a given dialysable solute during the passage through the dialyser, and this decrease in turn depends on the molecular size of the solute. Thus in solutes of high molecular weight and with poor dialysance a high distortion value by ultrafiltration has to be expected.

REFERENCES