

Dialyzer Clearances for Small Solutes at Low Dialysate Flow Rates

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Introduction

New, daily hemodialysis therapies use low dialysate flow rates to optimize the use of dialysate; however, dialyzer clearances for small solutes under these flow conditions have not been studied extensively. Previous work (Leypoldt & Cheung, Home Hemodial Int 1999) has shown that mass transfer-area coefficients for urea and creatinine decrease at low dialysate flow rates compared with those under conventional flow conditions (e.g., dialysate flow rates ≥ 500 ml/min).

Objectives

- To determine dialyzer clearances and dialysate saturation (defined as S = dialysate outlet concentration divided by plasma water inlet concentration) for small solutes (urea and creatinine) at low dialysate flow rates for a dialyzer containing PUREMA membranes.
- To compare dialyzer clearances and S for dialyzers containing PUREMA membranes with commercial dialyzers containing other polymer membranes.

Methods

Bovine blood (hct = $33 \pm 2\%$; TPP = 6.0 ± 0.5 g/dL) collected using citrate phosphate dextrose anticoagulant was thermostated to 37°C . Blood and dialysate were pumped in a single pass fashion through the dialyzer using the NxStage System One. Blood and dialysate samples were taken at the inlets and outlets of the dialyzer after 8 minutes of steady state flow. All experiments were performed 3 times and plasma concentrations of urea and creatinine were analyzed in a central laboratory by a clinical analyzer (Dimension RX-L, Dade-Behring). Blood flow rates were measured using a flow monitor HD01 (Transonic Systems, Ithaca, NY).

Tests were performed using three dialyzers with different membrane materials but similar surface areas:

- Purema (1.46 m^2 , NxStage Medical, Lawrence, MA)
- Polysulfone (1.6 m^2 , Optiflux F160NR, Fresenius North America, Ogden, UT)
- Synphan (1.46 m^2 , NxStage Medical, Lawrence, MA)

The following flow rates were investigated:

- Blood flow rate Q_b: 400 mL/min
- Dialysate flow rate Q_d: 40, 80, 120, 160, and 200 ml/min
- Ultrafiltration flow rate Q_f: 0, 1, and 2 L/hr

Blood- and dialysate-side clearances (K_{bD} , K_{dD}), dialysate saturation (S), and mass balance error for urea (MBE) were calculated using

$$K_{bD} = \frac{Q_{bwo} \cdot C_{bwo} - Q_{bwi} \cdot C_{bwi}}{C_{bwi} - C_{bdo}}; K_{dD} = \frac{Q_{dD} \cdot C_{dD}}{C_{bwi} - C_{bdo}}$$

$$S = \frac{C_{dD}}{C_{bwi}}$$

$$MBE(\%) = \frac{(Q_{bwo} \cdot C_{bwo} + Q_{dD} \cdot C_{dD}) - (Q_{bwi} \cdot C_{bwi} + Q_{di} \cdot C_{di})}{Q_{bwi} \cdot C_{bwi} + Q_{di} \cdot C_{di}} \cdot 100$$

with Q_{di}, Q_{dD} inlet and outlet dialysate flow rates
C_{di}, C_{dD} inlet and outlet dialysate concentrations
Q_{bwi}, Q_{bwo} inlet and outlet blood water flow rates
C_{bwi}, C_{bwo} inlet and outlet blood water concentrations

The blood water flow rate (Q_{bwi}) was calculated from the blood flow rate (Q_b) and the hematocrit (H):

$$Q_{bwi} = \left[\frac{H}{100} \cdot 0.8 + \left(\frac{100 - H}{100} \right) \cdot 0.93 \right] \cdot Q_b$$

Results

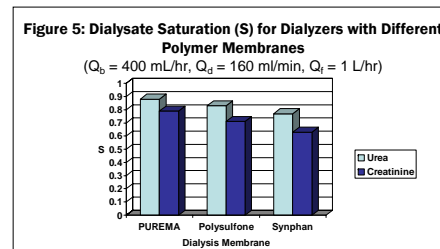
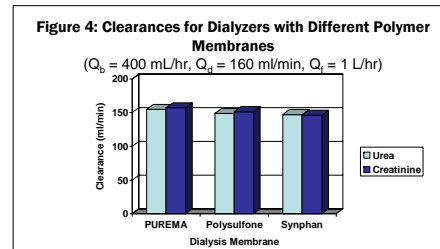
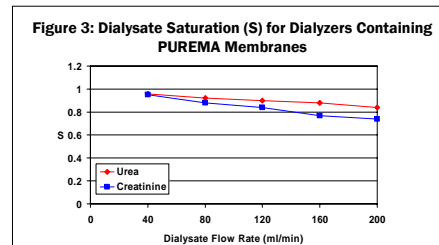
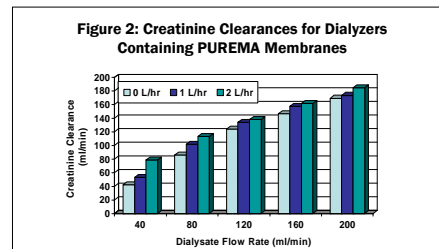
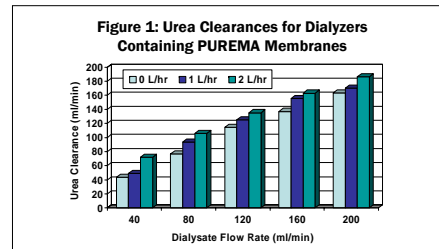
MBE for urea for all 69 experiments was 0.77 ± 0.69 (SEM)%, a value not different from zero.

The urea and creatinine clearances and the dialysate saturation for the dialyzers containing the PUREMA membranes are shown in Figures 1, 2, and 3, respectively. Figures 4 and 5 show the clearance and dialysate saturation for the three membranes investigated.

Urea and creatinine clearances increased with increasing dialysate flow rate (P<0.0001) and ultrafiltration flow rate (P<0.0001).

Urea and creatinine S were independent of ultrafiltration flow rate but varied inversely with dialysate flow rate (P < 0.0001).

S for urea and creatinine was higher (P < 0.05) for PUREMA than for Synphan membranes but similar to those for Optiflux 160NR dialyzers containing polysulfone membranes.



Conclusion

Dialyzer clearances for urea and creatinine approximate dialysate flow rates at low dialysate flow rates.

Dialyzers containing PUREMA membranes are more efficient at clearing small solutes than those containing Synphan membranes.