IMPACT OF SOLUTE EXCHANGE BETWEEN ERYTHROCYTES AND PLASMA ON HEMODIALYZER CLEARANCE

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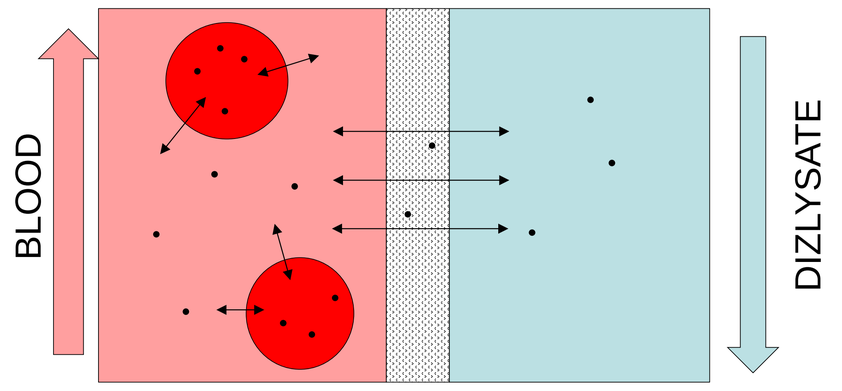
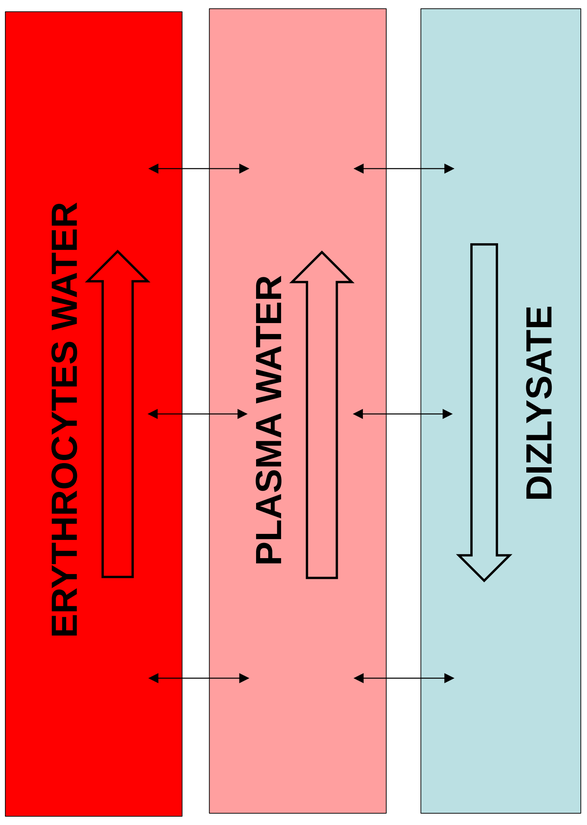
OBJECTIVES

During the flow of blood through hemodialyzer small solutes are removed from plasma to dialysis fluid across the dialyzer membrane and from erythrocytes to plasma across the cellular membrane. The rate of exchange of solutes between cells and plasma influences the performance of hemodialyzer. A mathematical model was applied to assess the impact of this exchange on the effective hemodialyzer clearance.



METHODS



The model describes the flow of solutes in the countercurrent dialyzer with one phase flow of dialysis fluid in the dialysate channel and two phase flow of plasma water and water in cellular blood components (erythrocytes) in the blood channel. The one dimensional approach to the distribution of solute concentration in the channel cross-section is assumed. The channels are characterized by their volumes and the solute transport characteristics by diffusive permeability of the dialyzer membrane KoA, the transmittance coefficients of the dialyzer, and the diffusive permeability of cellular membrane, PAer. The rate of ultrafiltration is assumed to be constant. Computer simulation of the model predicts the profile of the solute distribution along the dialyzer channels, the change of the profiles with time, and three clearances: 1) dialyzer clearance KD calculated using the amount of solute removed with dialysate over its concentration in inlet plasma, 2) plasma clearance KP calculated using the amount of solute removed from plasma over its concentration in inlet plasma, 3) erythrocyte clearance KE calculated using the amount of solute removed from erythrocytes to plasma over the difference in its concentration in inlet cellular water. The typical values of the volumetric flow rates in dialyzer and dialyzer membrane diffusive permeability for urea and creatinine were assumed. The cellular membrane permeability for urea and creatinine were taken as estimated in [1].

RESULTS

For the constant solute concentrations in plasma water and cellular water at the inlet to dialyzer the steady state of the transport in dialyzer is obtained after around two minutes for both solutes. The results were however much different for urea and creatinine, Fig 1. The urea concentrations profiles in plasma water and cellular water are similar along the dialyzer and the system behaves as the removal was from the whole water in the blood channel. In contrast, the creatinine concentration in cellular water changes only slightly along the dialyzer and the system may be approximated as the removal of creatinine from plasma water.

For a standard dialysis (blood and dialysis fluid inflow of 300 and 500 mL/min, respectively, zero ultrafiltration, hematocrit 35%), permeability of dialyzer membrane KoA = 789 and 556 mL/min, and permeability of cellular membrane PAer = 78400 and 4.4 mL/min for urea and creatinine, respectively, the clearances for urea were KD = 219.5, KP = 162.0, KE = 64.3 mL/min and KD = 169.9, KP = 165.0, KE = 2.2 mL/min for creatinine.

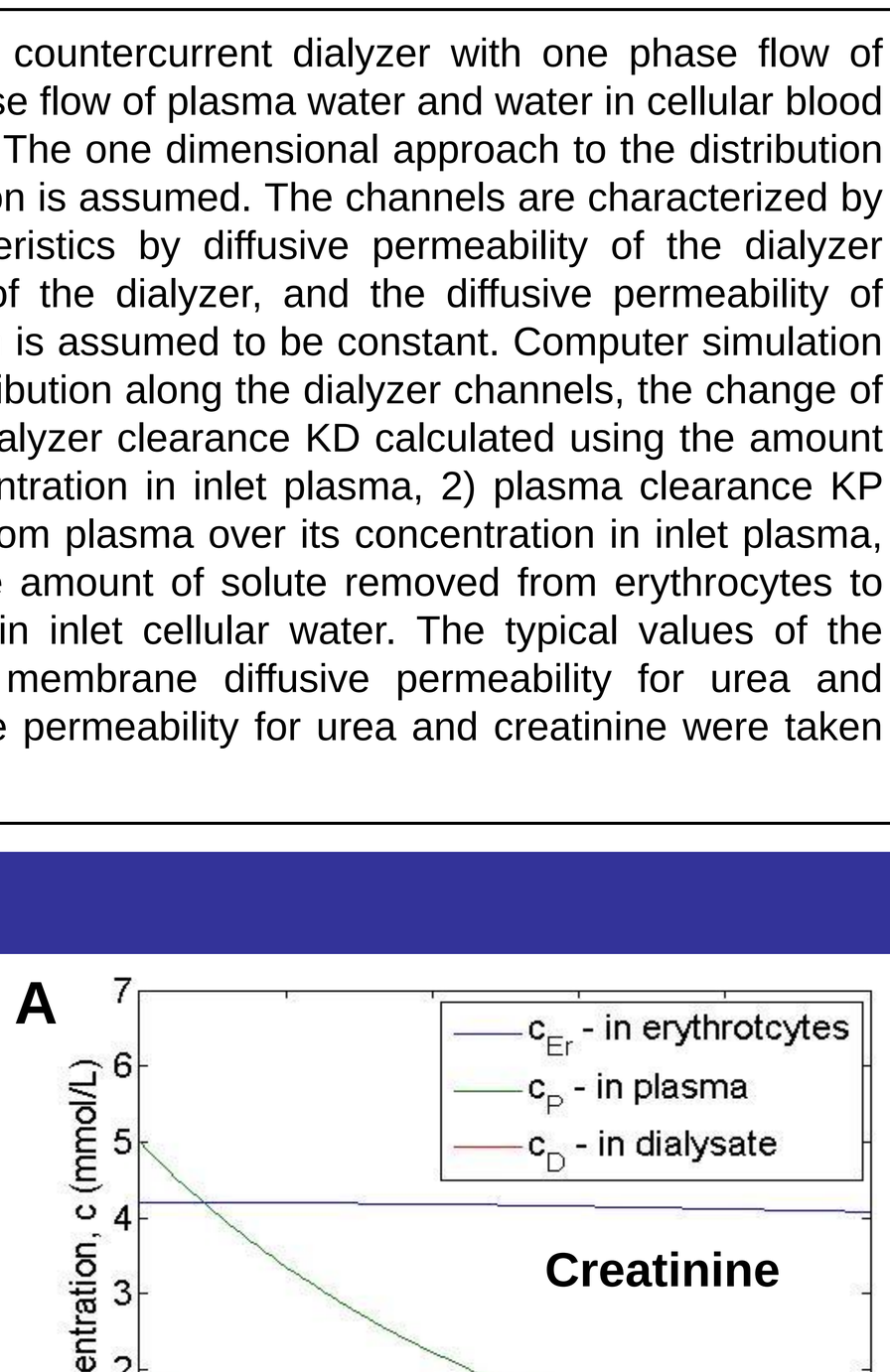


Figure 1. The steady state of the distribution of **(A)** creatinine and **(B)** urea concentration in plasma, erythrocyte water and dialysate along the dialyzer. Note that blood enters the dialyzer (x = 0) with slight disequilibrium in urea concentration between plasma and erythrocyte water.

CONCLUSIONS

The highly different diffusive permeability of cellular membrane for urea and creatinine yields much different contribution of blood cellular compartment to the removal of these solutes

REFERENCES

[1] Schneditz D, Platzer D, Daugirdas JT. A diffusion-adjusted regional blood flow model to predict solute kinetics during haemodialysis, *Nephrol Dial Transplant* (2009) 24:2218-2224

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