GREEN AND EFFICIENT DIALSYIS: A CONTRADICTION IN TERMS?

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Introduction

Hemodialysis (HD) is currently performed with dialysate flows in the range 500-700mL/min in HD and hemodiafiltration (HDF) mode. With a standard daytime dialysis scheme of three times four hours a week, and accounting for a 60% efficiency of the reverse osmosis water installation, each patient consumes up to ~31.000-50.000L per year. Lowering dialysate flow may impact the diffusive toxin transport, driven by the concentration gradient. However, also fiber diameter and membrane porosity play a role in the diffusive transport [1]. Hence, for the same blood and dialysate flow, the choice of the dialyzer will determine toxin transport.

The aim of this study was to check if sufficient solute removal can be achieved when using a lower dialysate flow, and as such consuming less water. We therefore quantified instant and overall removal of representative uremic toxins in HDF with high dialysate flow Q_D in a high flux dialyzer *versus* HD with a medium cut-off dialyzer either without and with lowering Q_D.

Methods

Ten stable chronic HD patients with a well-functioning vascular access and no active inflammation or malignancy were included. Patients were randomized in a cross-over study with three midweek sessions of 240min with patient's usual blood flow: 1) post dilution HDF with FX800 Cordiax dialyzer (Fresenius Medical Care, Germany), Q_D 700mL/min, and auto substitution rate (HDF-700); 2) HD with Theranova 400 dialyzer (Baxter, USA) and Q_D 700mL/min (HD-700); and 3) HD with Theranova 400 and Q_D 300mL/min (HD-300). All sessions were performed on a 5008 dialysis machine (Fresenius Medical Care, Germany), with ultrafiltration rates according to the needs of the patient.

Blood was sampled 5min after the start of each test session from the arterial and venous dialysis blood lines to calculate dialyzer extraction ratio (ER - %). From the spent dialysate line, sampling was performed at 5, 30, 90, and 240min, to calculate total solute removal (TSR) from the AUC. All blood and dialysate samples were analyzed for urea, phosphate, beta-2-microglobulin (B_2M), and myoglobin.

Results

The ten included patients (age 55.6±19.0; 6 male) were dialyzed thrice for 240min, with no difference between the sessions in blood flow [thrice 300mL/min (n=9) and 350mL/min (n=1)], and ultrafiltration rate (i.e. 2.1[1.4;2.6]L, 2.0[1.1;2.4]L, and 2.0[1.4;2.6]L).

Two patients had a central venous catheter, i.e. Bard Hemostar 14.5Fr (Becton Dickinson, USA) and Palindrome 14.5Fr (Medtronic, USA). No adverse or bleeding events were recorded.

Serum concentrations of the four toxins were not different at the dialysis start of the three midweek sessions. Water consumption, ERs and TSRs are shown in Table 1. While ERs were not different among the three strategies, overall TSR was lower with HD-300 *versus* HDF-700, while TSR with HD-700 was not different from TSR with HDF-700.

	Post HDF	HD_700	HD_300	ANOVA
Consumption/session	**189L**	**168L**	**72L**	**P-vlaue**
ER (%)				
Urea	87.7 ± 7.9	87.8 ± 7.8	81.2 ± 9.3	0.180
Phosphorus	83.2 ± 5.5	81.5 ± 6.7	79.3 ± 6.4	0.402
β_2M	50.5 ± 11.0	47.2 ± 11.8	38.8 ± 6.3	0.050
Myoglobin	34.1 ± 9.7	31.7 ± 11.7	25.2 ± 6.1	0.128
TSR				
Urea (g)	53.2 ± 26.3	44.1 ± 17.6	25.3 ± 12.2$^{\alpha}$	**0.018**
Phosphorus (mmol)	61.7 ± 25.8	48.6 ± 22.9	29.9 ± 11.1$^{\alpha}$	**0.012**
β_2M (mg)	273 ± 144	225 ± 188	138 ± 46	0.125
Myoglobin (mg)	5.28 ± 0.77	4.72 ± 0.45	2.37 ± 0.67$^{\beta\gamma}$	**<0.001**

Table 1: Extraction Ratio (ER) and Total Solute Removal (TSR). $^{\alpha}$ P<0.05 vs HDF-700; $^{\beta}$ P<0.001 vs HDF-700; $^{\gamma}$ P<0.001 vs HD-700

Discussion

Aiming for a more environmentally friendly dialysis becomes more and more important, and herewith, reducing water consumption is one of the cornerstones. Since a reduction in water consumption might however come at the expense of a decrease in dialysis efficiency, the present study compared water use and toxin removal in different dialysis modalities, using different dialysate flows and dialyzers. Comparing HD with a Theranova dialyzer and 300mL/min dialysate flow resulted in a decrease of 62% in water consumption, but also a decrease in toxin removal of 49-55% as compared to post dilution HDF with an FX800 dialyzer and 700mL/min dialysate flow. Switching from this HDF_700 modality to HD with Theranova dialyzer and 700mL/min dialysate flow reduces toxin removal by 11-21% with a decrease of only 11% in water consumption. A deeper understanding of how different treatment settings affect solute clearance and clinical endpoints should help in rationing water use and tailoring patient-specific recommendations for dialysis modality, dialysis fluid flow, dialyzer membrane, and treatment duration.

References

1. Kirsch et al, Nephrol Dial Transpl, 32:165-172, 2017