

LONG-TERM EXPERIENCE WITH HYPERTONIC HAEMODIAFILTRATION

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Summary

Our long-term experience and the preliminary results of a cross-over study show that hypertonic haemodiafiltration is a valuable and safe procedure: patients report an increased generalized wellbeing during and in between treatments; there is no deterioration of the routine blood chemistry in spite of a reduction of more than 30 per cent in the treatment time. Furthermore, no arterial hypertension or fluid overload is observed, due to accurate sodium modelling that guarantees an adequate negative sodium balance. Hypertonic haemodiafiltration may become a routine method for the long-term treatment of chronic uraemia.

Introduction

In the last few years we have developed a model of haemodiafiltration in which acetate haemodialysis is combined with a high flux dialyser (Biospal 3000S, polyacrylonitrile membrane, 1.2m², Hospal), a high ultrafiltration flow rate with a volumetric ultrafiltration control (Monitral System, Hospal) and a post-dilution hypertonic reinfusion containing only sodium, chloride and bicarbonate (sodium concentration 180 or 220mmol/L, according to the planned weight loss). We named this technique hypertonic haemodiafiltration [1].

Sodium modelling

In previous studies we have defined the rationale of the hypertonic haemodiafiltration sodium modelling [1,2]: briefly, assuming that no Na flux occurs through diffusion from the dialysate compartment to the patient when using an Na concentration in the incoming dialysate ($[Na^+]_{Dj}$) \sim 135mmol/L, the Na balance (N_{Na^+}) is simply given by the difference between the sodium mass ultrafiltered (Na^+_{UF}) and the sodium mass administered to the patient through the hypertonic reinjection solution (Na^+_{R}). We have been able to confirm this

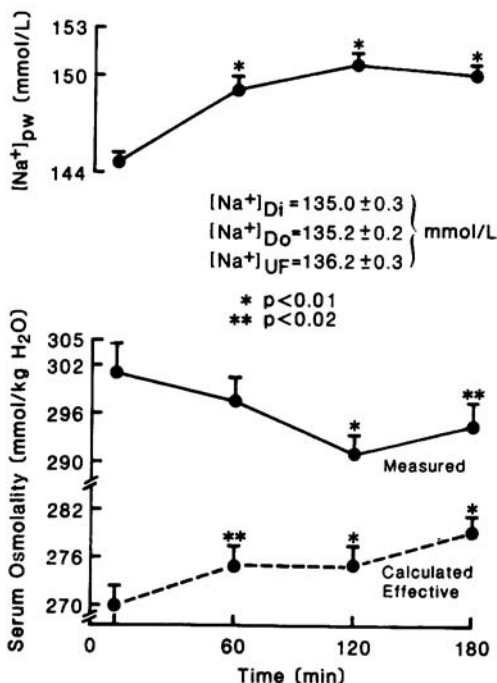


Figure 1. Serum osmolality and sodium concentration in the incoming dialysate ($[Na^+]_{Di}$), outgoing dialysate ($[Na^+]_{Do}$), in the ultrafiltrate ($[Na^+]_{UF}$) and in the plasma water ($[Na^+]_{pw}$) of seven patients undergoing twice a session of hypertonic haemodiafiltration. Effective osmolality was calculated, subtracting the osmolal contribution of BUN from the measured osmolality [3]. Means \pm SEM. Paired Student's 't' test

in the series of experiments shown in Figure 1: seven patients underwent twice (the results of both experiments are averaged for each patient) a session of hypertonic haemodiafiltration with $[Na^+]_{Di} \sim 135$ mmol/L. As expected, the sodium concentration in the outgoing dialysate ($[Na^+]_{Do}$) was never less than $[Na^+]_{Di}$. If for the sake of simplicity we assume $[Na^+]_{Di} = [Na^+]_{Do}$, NNa^+ is at least $= Na^+_{UF} - Na^+_R$ (1).

Our further hypothesis is that the inter-dialysis water intake is hypotonic and that the relationship between weight gain and salt intake is not linear: the larger the weight gain, the lower will be the sodium/water loading ratio (increasing dissociation between water and salt intake). Consequently, the dialysis must fit this dissociation with an equally dissociated water and sodium removal, in order to prevent the dialysis disequilibrium syndrome symptoms.

On the basis of these hypotheses we constructed a theoretical curve in which a well-defined NNa^+ fits a specific weight loss desired at the end of the treatment (Figure 2). The next step was to elaborate tables in which, utilizing the equation (1), we could define the ultrafiltration and reinfusion rates necessary to achieve the desired NNa^+ and weight losses, as indicated in Figure 2.

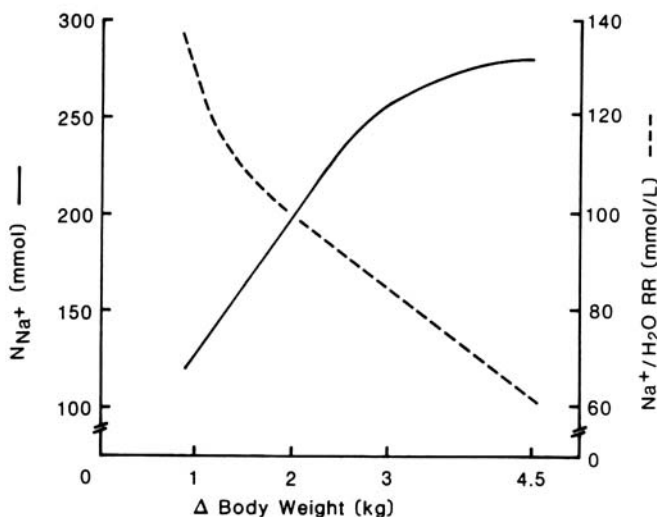


Figure 2. The two curves show the relationship of the weight loss (Δ body weight) with both the sodium mass balance (N_{Na^+}) and the sodium/water removal ratio (Na^+/H_2O RR), according to the sodium modelling of hypertonic haemodiafiltration

Patients and methods

More than 4000 hypertonic haemodiafiltrations have been performed in our dialysis unit: 12 patients have been treated successfully (3 x 3hr/wk) with hypertonic haemodiafiltration (blood flow rate \sim 400ml/min) for the past 23.7 ± 4.2 SEM months.

TABLE I. Clinical and biochemical parameters (means \pm SEM) in six patients undergoing a cross-over study of four months of hypertonic haemodiafiltration (H HDF) and four months of haemodialysis (HD)

	H HDF		HD
BUN (mmol/L)	28.0 \pm 1.9		28.4 \pm 1.6
Creatinine (mmol/L)	1.31 \pm 0.09		1.25 \pm 0.09
Uric acid (mmol/L)	0.51 \pm 0.03		0.54 \pm 0.04
Calcium (mmol/L)	2.25 \pm 0.05		2.28 \pm 0.05
Phosphorus (mmol/L)	1.67 \pm 0.27		1.75 \pm 0.35
Sodium (mmol/L)	139.4 \pm 0.7	*	137.9 \pm 0.7
Potassium (mmol/L)	4.7 \pm 0.2		5.0 \pm 0.2
Systolic	127 \pm 11		128 \pm 10
Diastolic	83 \pm 7		84 \pm 7
} BP – pre (mmHg)			
Δ body weight (kg)	3.2 \pm 0.3	*	2.6 \pm 0.2
Body weight – post (kg)	79.9 \pm 8.6	*	80.9 \pm 9.0

Paired Student's 't' test. * $p < 0.05$

Furthermore, we have started a long-term cross-over study in another group of 11 patients. Table I shows the comparative data of six of them, who have undergone four months of haemodialysis and four months of hypertonic haemodiafiltration in a random sequence. During the study haemodialysis treatment was administered in a way believed to be 'adequate' at that time for each of them: the blood flow was ~ 250 ml/min; $[\text{Na}^+]_{\text{Di}}$ was 135 mmol/L for five patients and 140 mmol/L for the last one; one patient had bicarbonate dialysis; hollow fibre (5 cuprophan, 1 cellulose acetate) dialysers 1.1 to 1.4 m² were used.

Hypertonic haemodiafiltration was administered as described in the introduction section. Blood flow was ~ 400 ml/min. The treatment time was reduced from 305 ± 19 min in haemodialysis (range 240–360 min) to 210 ± 13 min in hypertonic haemodiafiltration (range 180–240 min) ($p < 0.001$).

Results

We observed during the hypertonic haemodiafiltration period:

1. An increased generalized wellbeing: an improvement in sharpness, alertness, sleep patterns and muscle strength was reported. Neurophysiological and neuropsychological tests are in progress to try to quantify this increased wellbeing.
2. An improvement in dialysis tolerance and cardiovascular stability: for example, headache and symptomatic hypotension were reported in 18.4 and 13.2 per cent of haemodialyses, whereas they were present in only 5.6 and 3.0 per cent of hypertonic haemodiafiltrations. The most plausible explanation is that the increased effective osmolality (Figure 1) mediates an adequate vascular refilling.
3. No deterioration of the monthly blood results in spite of a reduction of more than 30 per cent in the treatment time: only a significant increase of serum Na, however still in the normal range, was found in the hypertonic haemodiafiltration period (Table I).
4. No increase in blood pressure (Table I); a significant increment in the weight gain, due to the increased thirst and appetite, was recorded (Table I); however, we could easily decrease the 'ideal' body weight of the patients, thanks to the better cardiovascular stability during treatment, in order to match the larger weight gain with a lower 'ideal' body weight (Table I).

Discussion

Haemodiafiltration possesses the characteristic, which is unique in the field of the extracorporeal treatment of chronic uraemia, of providing a balanced removal of small and middle molecules [4,5]. This feature, associated with the improvement of the wellbeing during and in between treatments, makes hypertonic haemodiafiltration more adequate than haemodialysis. A concern could be raised about the possibility of arterial hypertension or fluid overload, when treating

patients with hypertonic haemodiafiltration; however, this concern has no right to exist, because our sodium modelling guarantees an adequate NNa^+ . Furthermore, our long-term experience and the results, although preliminary, of this cross-over study, do not support it.

In conclusion, hypertonic haemodiafiltration has all the requisites necessary for becoming a routine method for the long-term treatment of uraemia.

Acknowledgments

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