CHANGES IN BODY COMPARTMENTS ON DIFFERENT TYPES OF HAEMODIALYSIS


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Summary

Changes in plasma volume (PV), extracellular volume (ECV) and intracellular volume (ICV) were studied in seven patients on conventional haemodialysis (HD) and in six patients on stable hypertonic HD. Weight loss and ultrafiltration were similar in both groups.

Before HD the spaces of $^{125}$RISA (PV), $^{35}$SO$_4$Na$_2$ (ECV) and $^3$H$_2$ (total body water, TBW) were simultaneously determined ICV = TBW - ECV. At the end of HD the space of $^{35}$SO$_4$Na$_2$ was again tested.

PV and ECV diminished more on conventional HD than on hypertonic HD, whereas ICV increased on conventional HD and decreased on hypertonic HD.

The handling of plasma osmolality during HD is an effective method for modifying transcompartimental body fluid shifts in HD by distributing weight loss between intracellular and extracellular spaces allowing for a better maintenance of plasma volume.

Introduction

Intradialytic morbidity is a common phenomenon attributed to plasma volume removal and haemodynamic changes during haemodialysis (HD). Rapid decrease in plasma osmolality is in part responsible for this phenomenon [1] and a slower decline in plasma osmolality ameliorates clinic symptomatology [2] and preserves plasma volume (PV) [3].

In acute dialysis studies the use of high sodium dialysate showed that volume removal in HD was due to intracellular (ICV) and extracellular (ECV) loss [4]. Chronic hypertonic HD with alternate and sudden changes in sodium dialysate (cell-wash dialysis) achieves intracellular dehydration but produces thirst and greater weight gain between dialyses which limits its use on short-time routine programmes [5]. Haemodiafiltration employing hypotonic dialysate and hypertonic haemofiltration solution allows a reduction in dialysis time by altering the rate of decline of plasma osmolality which favours vascular stability without changes or weight gain [6].
In order to avoid high end-dialysis plasma sodium concentrations associated with greater thirst and weight gain, we have performed short-time chronic HD using a low sodium dialysate and perfusing into blood a small volume of hypertonic sodium chloride. The aim of this study has been to evaluate the changes in PV, ECV and ICV on conventional HD and hypertonic HD.

Methods

Thirteen male patients were studied. Seven patients aged 43.7±10.2 years and weighing 65.4±9.5kg (dry weight), had been on conventional HD for 74.8±40 months, 4x3hr/week, using dialysate containing: Na 138mEq/L, K 2mEq/L, Ca 4mEq/L, Mg 1.5mEq/L, acetate 40mEq/L, glucose 3g/L and osmolality 307mOsm/L.

Six patients aged 45.6±14.2 years, weighing 58.5±5.3kg and having been on HD for 55.8±32.7 months were placed for one month on a stable regimen of hypertonic HD, 3x3hr/week, using dialysate containing: Na 130mEq/L, K 2mEq/L, Ca 3mEq/L, Mg 1.5mEq/L, acetate 32mEq/L, glucose 4g/L and osmolality 295mOsm/L. During the first and last 20 minutes of the first hour of HD, 171mEq of NaCl (50ml of 20% NaCl) and for the last two hours of HD, 60mEq of NaHCO₃ (60ml of 1M NaHCO₃), were infused into the venous return-line.

All patients were dialysed with an UF control device using an AN-69 membrane dialyser (Hospal, H.12 –10) with blood flow of 250ml/min and dialysate flow rate of 500ml/min.

The day on which body compartments were evaluated, no food or fluid intake were permitted prior to starting the study (8 and 3 hours respectively) until the completion of any given volume determination. In order to avoid fluid replacement during HD, patients were kept ½kg above their usual dry weight.

One hour before HD, patients were injected with 90μCi of ³H₂O, 75μCi of Na₂³⁵SO₄ and 5μCi of ¹²⁵I for TBW, ECV and PV determination respectively [7]. Equilibration time was considered for ¹²⁵I at 10 minutes and for ³H₂O and Na₂³⁵SO₄ at 45 minutes. Initial ICV was calculated: TBW - Initial ECV. Changes in hourly and post-HD PV were determined by changes in serum albumin concentration (Alb): PV post = PV₀ x Alb₀/Alb post (o=initial). Sodium and plasma osmolality were measured hourly.

At the end of HD, 75μCi Na₂³⁵SO₄ were again given for repeat ECV determination. Final TBW was assumed to be equal to: Initial TBW – weight loss in HD. Final ICV was calculated: Final TBW – final ECV.

Data were statistically analysed by the Student’s ‘t’ test for unpaired data.

Results

Changes in serum sodium concentration, plasma osmolality and PV during and after both types of HD are shown in Figure 1. It is important to note that PV decrease was less on hypertonic HD than on conventional HD.

The group of patients on conventional HD had a weight loss of 1900±381g with an ultrafiltration volume of 2484±314ml. Initial TBW and PV were 38426±3173ml and 3795±823ml respectively. Pre and post HD ECV and ICV were
Figure 1. Changes in serum concentration, osmolality and plasma volume during and after haemodialysis.
12233±1922ml versus 9920±1960ml (ΔECV: -2312±652ml) and 26193±3789ml versus 26604±3529ml (ΔICV: +411±794ml) respectively.

The group of patients on hypertonic HD had a weight loss of 1866±668g with an ultrafiltration volume of 2453±496ml. Initial TBW and PV were 35546±3388ml and 3426±396ml respectively. Pre and post HD ECV and ICV were 9829±1334ml versus 8939±1146ml (ΔECV: -1057±734ml) and 23504±4632ml versus 22701±4603ml (ΔICV: -839±685ml) respectively.

Percentage changes obtained from each patient in body compartments on both types of HD are summarised in Table I. Whereas in conventional HD ICV rose, being weight loss exclusively due to ECV decrease, in hypertonic HD weight loss was due both to ECV and ICV decrease which was associated with improved maintenance of PV.

**TABLE I. Percentage changes in body fluid compartment volume on haemodialysis**

<table>
<thead>
<tr>
<th></th>
<th>Conventional haemodialysis</th>
<th>Hypertonic haemodialysis</th>
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</thead>
<tbody>
<tr>
<td><strong>Number of patients</strong></td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td><strong>Dry body weight</strong></td>
<td>65.4 ± 9.5kg NS</td>
<td>58.5 ± 5.3kg</td>
</tr>
<tr>
<td><strong>Weight loss</strong></td>
<td>1900 ± 387g NS</td>
<td>1866 ± 668g</td>
</tr>
<tr>
<td><strong>Ultrafiltration</strong></td>
<td>2484 ± 314ml NS</td>
<td>2453 ± 496ml</td>
</tr>
<tr>
<td><strong>Δ Plasma volume</strong></td>
<td>-14.48±6.41% *</td>
<td>-5.41±4.53%</td>
</tr>
<tr>
<td><strong>Weight loss ascribed to plasma volume</strong></td>
<td>-24.61±8.93% *</td>
<td>-12.22±10.65%</td>
</tr>
<tr>
<td><strong>Δ Extracellular volume</strong></td>
<td>-19.35±6.26% *</td>
<td>-10.37±7.36%</td>
</tr>
<tr>
<td><strong>Weight loss ascribed to extracellular water</strong></td>
<td>-126.53±51.23% *</td>
<td>-53.93±37.43%</td>
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<tr>
<td><strong>Δ Intracellular water</strong></td>
<td>+1.74±3.28% *</td>
<td>-3.44±3.80%</td>
</tr>
<tr>
<td><strong>Weight loss ascribed to intracellular water</strong></td>
<td>+26.53±51.23% *</td>
<td>-46.07±37.43%</td>
</tr>
</tbody>
</table>

* p<0.05

Effects of conventional and hypertonic HD on each body compartment are shown in Figure 2. It is of interest to note that while conventional HD produces ICV overhydration, hypertonic HD results in ICV dehydration that implies an important qualitative change on HD.

**Discussion**

Clinical tolerance to haemodialysis has usually improved with higher sodium dialysate which reduces the relatively rapid decrease in plasma osmolality during HD, but produces thirst and greater interdialytic weight gain [8]. Thus, by increasing plasma osmolality through a high sodium dialysate, it is difficult to avoid chronic extracellular volume expansion related to raised total body sodium content that limits the long-term use of this method.

In our study we varied the rhythm of plasma osmolality decrease using a low sodium dialysate and perfusing into blood hypertonic NaCl at the beginning of HD to increase plasma osmolality above basal values during the first hour of
Figure 2. Distribution of body compartment volume removal in haemodialysis. □=conventional haemodialysis (n=7). ■=hypertonic haemodialysis (n=6); * p<0.05

dialysis and achieving a negative sodium balance at the end of HD. By this method, plasma osmolality at the end of HD is similar to that of conventional HD, but whereas in hypertonic HD volume removal comes from both intracellular and extracellular compartments with improved maintenance of PV, in conventional HD volume removal is exclusively due to ECV with subsequent ICV hydration and decrease in PV stability.

Intradialytic weight gain did not significantly change over this study; this fact allowed good clinical tolerance to ultrafiltration on short-time HD. In hypertonic HD and specially during its first hour and as in cell-wash dialysis [5], an intense ultrafiltration rate between intra and extracellular compartments must account for eliminating cellular overhydration, thereby improving microcirculation and facilitating solute transfer from cells to extracellular compartment.

The use of isotopic techniques pre and post HD allows simultaneous determination of changes in body compartments. Radioactive tracers, having a combined radiation exposure of a routine chest X-ray [9], appear to be a good method for evaluating the source of fluid removed and fluid shifts during HD, and therefore in this way should contribute to the improvement of dialysis efficiency and comfort.

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References