PART 3

Chairman: P Michielsen
Leuven
Belgium
Benefits Obtained by the Use of High Sodium Dialysate During Maintenance Haemodialysis

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It is customary for patients on regular haemodialysis to be dialysed against a fluid with a sodium concentration of around 130 mEq per litre (Robinson & Rosen, 1972). It is believed that this low level is necessary in order to control both hypertension and thirst (Moriarty & Parsons, 1966).

We felt that a sodium concentration nearer the physiological normal for plasma water might be of more benefit to the patient, in that it would specifically prevent sodium loss down the concentration gradient with consequential cellular overhydration and plasma volume reduction. Patients have been dialysed for a total of nine months with a dialysate containing 145 mM sodium per litre, and the results compared with those obtained on the same patients while dialysed against a sodium concentration of 132 mM per litre. This paper describes some of the benefits of high sodium dialysis, in terms of improved well-being, control of blood pressure, and the changes observed in body weight, plasma sodium concentrations and osmolalities.

METHODS

Nine patients, dialysed twice weekly for a total of 16-22 hours per week, were studied over a period of 15 months, which was divided into four consecutive phases. During phases 1 and 3 (duration three months each) dialysis-fluid containing 132.5 mM sodium per litre was used ('low sodium'). During phases 2 (five months) and 4 (four months) the dialysate sodium concentration was 145 mM per litre ('high sodium'). No antihypertensive drugs were used.

Dylade (Model B, Series 2) dialysate supply units were used with Travenol 'Ultra-flo 100' disposable coil units. Advantage was taken of our closed container system of negative pressure dialysis (Wakefield et al, 1970), in order to achieve the necessarily higher rates of ultrafiltration required during high sodium dialysis. Travenol 'Ultra-flo 145' coils were used for two weeks during phase 4 for five patients whose mean body weights were
thereby reduced by a total of 2 to 6 kg, in order to achieve better control of potential hypertension.

Plasma sodium concentrations were measured by flame emission photometry and osmolalities with an 'Osmette S' automatic osmometer.

RESULTS

It was apparent very soon that the patients all 'felt' very much better while on high sodium dialysis. There were fewer complaints of headaches, the number of vomiting episodes was reduced, and the patients were less tired, particularly the day following dialysis. In general they did not have any of the 'washed out' feelings commonly experienced after low sodium dialysis. Naturally it is difficult to quantify such impressions, but the change was obvious to both patients and staff. A further benefit was that the incidence of muscular cramps was greatly reduced (Stewart et al, 1972), from around 50% on low sodium dialysis to 13% while on high sodium dialysis.

The mean pre-dialysis diastolic blood pressures for eight of the patients during the four phases are shown (Figure 1). On low sodium dialysis during phase 1 the mean diastolic level (± SD) was 95 ± 10 mm Hg, becoming 102 ± 11 mm Hg during the first two months of phase 2. This change was statistically insignificant, however, the body weights of all patients were gradually reduced, with the result that the mean diastolic pressure for the last two months of phase 2 was reduced to 91 ± 7 mm Hg (P < 0.05). During phase 3, again on low sodium dialysis, the mean levels were insignificantly lower at

![Mean Pre-Dialysis Diastolic Blood Pressure ± S.D. (9 Patients)](image)

**Figure 1.** Mean pre-dialysis diastolic blood pressures during the four phases (for phases 2 and 4 the mean values for the first two and last two months are shown separately)
84 ± 7 mm Hg, and during the first two months of phase 4 the slight increase to 90 ± 7 mm Hg was again insignificant.

At this point in time it was decided to consider diastolic pressures of > 90 mm Hg as unacceptable. A period of intensive progressive weight reduction was instituted for the five patients whose mean diastolic pressures pre-dialyses were in the 90-100 mm Hg range. In all five patients blood pressures decreased with weight reduction, and after two weeks diastolic pressures of < 90 mm Hg were achieved. The net result was that the overall mean diastolic pressure for the last two months of phase 4 was 81 ± 6 mm Hg, a level considered acceptable. This was in fact significantly lower than the levels applicable while on low sodium dialyses during phase 1 (P < 0.01). All the mean values described above include the results for one patient with diastolic pressures >100 mm Hg during phase 1, whose hypertension had never previously yielded to ultrafiltration while on low sodium dialysis.

Shown as a bar above the histograms of the mean pressures (Figure 1) are the results for one patient whose pre-dialysis diastolic pressures never yielded. He began haemodialysis during phase 2 and was transplanted during phase 4, before control was achieved. Given time, we believe his elevated pressures also would have yielded, as did the other originally resistant hypertensive patient, included in the mean values throughout.

Mean post-dialysis diastolic pressure levels were consistently 10-15 mm Hg lower than pre-dialysis levels, but the patients were not overtly hypotensive.

The mean weight losses during dialysis, and by implication the gain between dialyses, were significantly greater during high sodium dialysis. This difference between the high and low sodium phases was consistent and repeatable, the mean weight loss (± SD) being 4.40 ± 0.81 and 4.03 ± 1.07 kg respectively during phases 2 and 4, and 2.51 ± 0.92 and 2.65 ± 0.76 kg respectively during phases 1 and 3 (P < 0.01 to < 0.001 comparing the high and low strengths). The increased weight gain between dialyses was interpreted by the patients as a further benefit, since they enjoyed drinking more! Thirst, however, was not a problem, being only transient between the first two or three dialyses on beginning high strength.

The differences in the mean pre- and post-dialysis plasma sodium concentrations for the various phases (Figure 2) were largely predictable. There was no significant difference in pre-dialysis plasma sodium concentrations, the mean levels for the four phases ranging between 139 and 142 mM per litre. There was however a highly significant difference in the mean post-dialysis concentrations, which were 136 and 134 mM per litre respectively while on low sodium dialysis (phases 1 and 3), and 146 and 142 mM per litre respectively while on high sodium dialysis (phases 2 and 4). This meant there was an average decrease of -5 mM per litre each dialysis
MEAN PLASMA SODIUM CONCENTRATIONS
(9 patients)

\[ [\text{Na}]_{d} \text{mEq/l} \]

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Figure 2. Mean pre- and post-dialysis plasma sodium concentrations during the four phases.

MEAN PLASMA OSMOLALITIES ± S.D.
(9 patients)

PRE-DIALYSIS MEANS = NO SIGNIFICANT DIFFERENCES
POST-DIALYSIS MEANS = P < 0.001

Plasma Osm.
mOsm/kg

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Figure 3. Mean pre- and post-dialysis plasma osmolalities during the four phases.

while on the low strength and an average gain of +3 mM per litre each dialysis while on the high strength.

There was no difference in the mean pre-dialysis plasma osmolalities (Figure 3) comparing the four phases, the respective mean levels being 317, 312, 315 and 316 mOsm per kg. The post-dialysis mean plasma osmolalities were significantly different comparing the high and low phases, being 280 and
278 while on low sodium dialysis and 298 and 300 mOsm per kg while on the high strength (P < 0.001). Thus the mean osmolality decrease during low sodium dialysis was -37 whereas during high sodium dialysis it was greatly minimised, only -15 mOsm per kg (P < 0.001).

DISCUSSION

There is no doubt that the patients benefited subjectively by the transfer to high sodium dialysis. What possible mechanism might explain this improvement and the associated objective changes observed?

Probably the main reason why few have tried high sodium strength dialysis is the widespread belief that it would produce disadvantageous hypertension (Moriarty & Parsons, 1966; Robinson, 1969). The control of hypertension by ultrafiltration has been previously described for low sodium dialysis (Comty et al, 1964) but one in eight patients have proved resistant (Editorial, 1969). Bilateral nephrectomy continues to be recommended for these resistant patients (Papadimitriou et al, 1969). Our results show that the control of hypertension by ultrafiltration can be achieved on high sodium dialysis also and that hypertension, far from being a problem under these conditions, can possibly be better controlled than on low sodium dialysis, once the appropriate post-dialysis weights have been achieved.

The syndrome or syndromes of 'disequilibrium' which commonly accompany maintenance haemodialysis have been described by many (Sokol et al, 1967; Shimia et al, 1967; Wakim, 1969). Symptoms variously include nausea, vomiting, headaches, post-dialysis fatigue, and hypertensive-hypotensive episodes. It is possible that muscular cramps should also be added to this list. These symptoms are all much reduced in frequency by high sodium dialysis, and the reason would seem to lie in the altered sodium status of the patients.

We believe that excessive plasma volume reduction is the mechanism which triggers off muscular cramps (Stewart et al, 1972). It is possible that it is excessive extra-cellular fluid volume reduction, perhaps combined with the additional effects of cellular overhydration, which is responsible for at least some, if not all, of the symptoms of disequilibrium under maintenance haemodialysis conditions. During high sodium dialysis there is no diffusional loss of sodium from the plasma to the dialyser down the concentration gradient, and therefore no consequential movement of water from extra-cellular fluid into cells, such as probably does occur during low sodium dialysis, when hyponatraemic blood plasma is returned to the patient. This means there is likely to be correspondingly less extra-cellular fluid volume reduction as well as no cellular overhydration, while on high sodium dialysis. Although the weight loss during dialysis was greater during high sodium dialysis, this does not necessarily imply that the extra-cellular fluid losses
were greater under these conditions.

Our conclusions, therefore, are as follows. Firstly, high sodium dialysis is capable of long-term use without the development of hypertension. Secondly, high sodium dialysis benefits the patients, in terms of improvement in general well-being and in the absence of cramps and fatigue. Thirdly, we believe these benefits are due to the maintenance of normal plasma sodium and osmolality levels post-dialysis, the avoidance of excessive extra-cellular fluid volume reduction and the relative absence of concomitant cellular overhydration, while on high sodium dialysis.

ACKNOWLEDGMENTS

We wish to express our gratitude to the Nursing and Technical Staff of the Artificial Kidney Unit for their careful and helpful observations, and to the Technical Staff of the Department of Medicine for their expertise in the biochemical analyses.

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OPEN DISCUSSION

E J DORHOUT MEES (Utrecht): I would like to congratulate Dr Stewart for his approach, in which he challenged something that was generally accepted but not proven, at least in my opinion. The first question I would like to ask is: have you looked at the potassium concentration and the changes in plasma concentration during and between dialyses? The second point is that you have rather high changes in body weights between dialyses: 2 kg with low sodium and 4 kg with high sodium. Was that correct since they are rather excessive? Finally, can you tell us something about the sodium content of the diet they were on?

STEWART: I am unable to answer your question about potassium in detail, except to say that I have noticed no remarkable values, either high or low. You were quite correct in the extent of the weight change. These patients are quite accustomed to going up and down between dialysis by 4 or 5 kg, but the point I want to make is that they feel quite well doing this. This is a concomitant, but not an unpleasant concomitant of living this way. They are indeed on very liberal diets, 60-80 g/day of protein with an injunction to avoid taking salt, but we know that they do drink more. In the absence of hypertension, I think no exception can be taken to this practice. We imagine they are taking 50 mM per day, but they are told to avoid salt.

H C BURCK (Tubingen): From the main value of the diastolic pressure, which was 91 ± 7 if I remember correctly, I conclude that you have mainly patients with a low diastolic pressure. Did you observe any patient with a high diastolic pressure – say over 110 diastolic, and how was his behaviour during high sodium dialysis?

STEWART: All of these patients bar two started off with diastolic pressures above 120, and were brought down progressively by this technique.

E RITZ (Heidelberg): Our limited experience with high sodium dialysis is in good agreement with the data you presented. However, our experience differs from yours in one point, in that our patients continued to complain about thirst even after the first few weeks. We have therefore been forced to abandon high sodium dialysate in quite a few patients. I wonder, whether excessive thirst might explain the gain of weight in your group of patients. They might well have dissimulated thirst.

STEWART: Well, it seems to be a choice between thirst or cramps. Our patients now have virtually no cramps and the patients prefer to go on. All these patients remain on high strength dialysate because both they, and the
nursing staff, tell me it is unethical to change back to low strength. The moment we try and switch them back for experimental purposes, everybody complains.

P MICHIELSEN (Leuven, Chairman): We have just time for a short question.

F M PARSONS (Leeds): You mentioned ultrafiltration, Dr Stewart. Did I get the impression that the high sodium dialysis regimen meant a greater degree of removal of water at each dialysis, or have I got that wrong?

STEWART: Your question is correct.

PARSONS: Aren’t you worried about increased removal of calcium by increasing the rate of ultrafiltration in patients who already have calcium problems?

STEWART: Well, we have had no overt calcium problems, that is to say people with fractures or the more obvious kinds of osteo-dystrophy. The alkaline phosphatases are a little bit up, I must admit, and most of these patients have some subperiosteal erosions. But my impression has not been that bone trouble is gross; I should add that we use a calcium concentration of about 7 mg/100 ml in the dialysate.