

## The effect of dietary salt restriction on hypertension in peritoneal dialysis patients

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**Background/aim:** To investigate the effect of dietary salt restriction on blood pressure levels, total sodium removal, and hydration status of peritoneal dialysis (PD) patients.

**Materials and methods:** Thirty-one stable PD patients who consulted a renal dietitian monthly for dietary recommendations, including restricted salt intake <5 g/day, and education about hypertension and hypervolemia were included in this study. Baseline and third month clinical and laboratory findings, bioelectrical impedance analysis results, and urinary and peritoneal sodium removal values were recorded.

**Results:** The mean age of the patients was 47.6 years and the mean time on PD was 39.6 months. The mean total sodium removal decreased slightly from 139.4 ± 69.1 to 136.2 ± 64.8 mmol/day ( $P > 0.05$ ) for the whole sample, and from 164.3 ± 70.9 to 154.2 ± 72.3 mmol/day ( $P > 0.05$ ) for the hypertensive subgroup (n: 17). Systolic blood pressure (from 134.3 ± 20.1 to 127.2 ± 19.5 mmHg,  $P: 0.01$ ), diastolic blood pressure (from 83.2 ± 12.0 to 77.4 ± 10.5 mmHg,  $P: 0.01$ ) and total body water (from 39.2 ± 10.9 to 38.3 ± 9.3 L,  $P: 0.04$ ) decreased significantly.

**Conclusion:** We demonstrated that even a little reduction in daily dietary sodium intake caused significant decreases in blood pressure levels and fluid overload.

**Key words:** Bioimpedance analysis, hypertension, hypervolemia, peritoneal sodium removal, salt intake, salt restriction

### 1. Introduction

Cardiovascular disease is the most important cause of morbidity and mortality in peritoneal dialysis (PD) patients with end stage renal disease (1,2). In common with the general population, hypertension is the leading factor for cardiovascular diseases and is rather common in PD patients (3). Due to some hemodynamic advantages of PD over hemodialysis, older studies suggest that control of hypertension is easier with PD than hemodialysis (4). However, later studies with larger sample sizes demonstrated that hypertension remains an important problem for PD patients (1,5).

Chronic fluid overload is regarded as the main cause of hypertension in PD patients (6). A recently published EuroBCM study, the first large multicenter study of hydration status in European PD patients, also underlined the fact that fluid overload is a frequent problem in this group of patients (25% of 639 PD patients were severely fluid overloaded) and relying only on clinical parameters for its assessment might be misleading (7). The survival

of PD patients was reported to be directly correlated to the amount of water that could be excreted per 24 h (8,9). Therefore, the authors mainly focused on the adequacy of ultrafiltration and residual renal function (9,10). Interestingly, excessive salt intake, which is the primary driving force for fluid overload, is generally neglected. Currently, it is underlined that 'salt balance' should also be used as an adequacy parameter and a predictor of outcome as well as fluid balance in PD patients (10).

Regarding the fact that salt balance can be improved mainly by reducing salt intake, we aimed to investigate the effect of dietary salt restriction on the control of blood pressure levels and the total sodium removal in patients on PD.

### 2. Materials and methods

#### 2.1. Patient selection and classification

This study examined 50 clinically stable patients who had been undergoing PD therapy for more than 6 months

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at Gazi University Hospital, Ankara. Patients who were 18 years of age or older and who had been visiting our outpatient clinic monthly were included in the study. Exclusion criteria were a history of peritonitis in the previous 3 months, history of limb amputation, presence of a pacemaker or defibrillator, and inability to provide informed consent. During the study period (from May to August 2010) 1 patient died, 1 had renal transplantation, and 17 patients either refused to be on such a strict diet or quit the study during follow-up. The remaining 31 patients were included in the final evaluation. Sodium concentration in PD solutions of the study population was 132 mmol/L. Patients consulted a renal dietitian monthly for dietary recommendations including restricted salt intake <5 g/day according to the recommendations of European Best Practice Guidelines on nutrition (11). We also educated all patients about hypertension and hypervolemia, in order to increase their compliance to antihypertensive therapy and dietary recommendations. At the beginning and during the third month of follow-up, clinical and laboratory findings and bioelectrical impedance analysis results were recorded. The study was conducted according to the Helsinki Declaration and approved by the Ethics Committee of Gazi University School of Medicine. All patients gave their informed consent to participate in the study.

## 2.2. Blood pressure measurements and bioimpedance analysis

Brachial blood pressure was measured 3 times in every patient and average values were accepted as systolic and diastolic office blood pressures. Measurements were performed with a mercury sphygmomanometer in a sitting position after 10 min rest. Patients who usually took antihypertensive medication were asked to take their pills before the visit, and the number of antihypertensive drugs taken was also recorded. During clinical visits the antihypertensive treatment of each patient was reevaluated and, if appropriate, the number of drugs was decreased. Diuretics were neither started nor stopped in the follow-up period. Hypertension was defined according to the World Health Organization/International Society of Hypertension criteria (12) as systolic blood pressure (SBP)  $\geq 140$  mmHg and/or diastolic blood pressure (DBP)  $\geq 90$  mmHg using office blood pressure measurements, or being on current treatment with an antihypertensive drug. Our target blood pressure levels for the patients were below 135 mmHg for systolic and below 85 mmHg for diastolic values, according to the criteria of similar studies (13).

Bioelectrical impedance analysis (BIA) was performed with a Quadscan 4000 (Body Stat, UK) multifrequency bioimpedance spectrum analyzer in order to determine the volume status of the patients. Measurements were performed in the right calf at 4 frequencies (5, 50, 100,

and 200 kHz) in the supine position after patients had emptied their dialysis solutions. Extracellular water (ECW), intracellular water (ICW), and total body water (TBW) contents were measured by BIA. Percentage ECW and ICW values were calculated by dividing ECW or ICW over TBW.

## 2.3. Evaluation of fluid and sodium removal

At the beginning and during the third month of follow-up, plasma sodium concentration, urinary sodium removal (USR), and peritoneal sodium removal (PSR) values were calculated for all patients. USR was the product of 24-h urine volume (L) multiplied by the sodium concentration (mmol/L) in mixed urine. PSR was the value of sodium content in total instilled dialysates subtracted from the sodium content in drained dialysates. Total sodium removal (TSR) was the sum of USR and PSR. Daily urine output and ultrafiltration of the patients were recorded and total fluid removal (TFR) was calculated as the sum of these 2 parameters. Plasma, dialysate, and urine sodium concentrations were measured by indirect ionometry. Total body sodium load was the product of ECW multiplied by plasma sodium concentration (PNa).

## 2.4. Statistical analysis

Statistical calculations were performed using the Statistical Package for the Social Sciences (SPSS version 13.0). Significance was defined as a P value less than 0.05. Data are shown as mean  $\pm$  SD or as percentages. Standard descriptive statistics and paired sample t-test were used where appropriate.

## 3. Results

The average age of the total 31 PD patients was 47.6 years and the average time on PD was 39.6 months. Fifteen out of 31 were females and 16.1% of the patients were diabetics. Seventy-four percent of the patients (23/31) had the diagnosis of hypertension, and 17 out of 31 patients (54.8%) had blood pressures above the target levels at the first visit. Twenty-two out of 31 patients had a daily urine output more than 100 mL per day and they were using furosemide. The mean office systolic and diastolic blood pressures of the patients were recorded as  $134.3 \pm 20.1$  and  $83.2 \pm 12.0$  mmHg, respectively. The clinical and demographic characteristics of the study population are shown in Table 1.

After 3 months of salt restriction, the mean TSR level decreased from  $139.4 \pm 69.1$  mmol/day to  $136.2 \pm 64.8$  mmol/day ( $P > 0.05$ ). However, the mean SBP and DBP levels decreased from  $134.3 \pm 20.1$  mmHg to  $127.2 \pm 19.5$  (P: 0.01) and from  $83.2 \pm 12.0$  mmHg to  $77.4 \pm 10.5$  mmHg (P: 0.01), respectively. Moreover, mean TBW decreased from  $39.2 \pm 10.9$  L to  $38.3 \pm 9.3$  L (P: 0.04) and mean plasma sodium concentration decreased from  $137.3 \pm 4.4$  mmol/L to  $135.1 \pm 3.9$  mmol/L (P: 0.01). The number

**Table 1.** Demographic and clinical parameters of the study group.

	Study group (n: 31)
Age (year)	47.6 ± 14.9
Sex (M/F)	16/15
BMI (kg/m <sup>2</sup> )	26.1 ± 4.3
Time on PD (months)	39.6 ± 26.5
Diabetics (%)	16.1% (5 / 31)
Hypertensives (%)	74.2% (23 / 31)
Urine amount (mL/day)	708.1 ± 583.2
APD/CAPD	15/16
SBP (mmHg)	134.3 ± 20.1
DBP (mmHg)	83.2 ± 12.0
Smokers (%)	16.1% (5/31)

PD: Peritoneal Dialysis, BMI: Body mass index, M: Male, F: Female, APD: Automated peritoneal dialysis, CAPD: Continuous ambulatory peritoneal dialysis, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

of antihypertensive medications per day decreased slightly, but was not statistically significant ( $1.55 \pm 1.23$  vs.  $1.48 \pm 1.15$ ,  $P > 0.05$ ). The percentage of icodextrin usage did not change significantly between the first and the last visits (67.7% vs. 70.9%,  $P > 0.05$ ). The percentage of erythropoietin stimulating agent (ESA) usage was also similar between the first and the last visits (54.8% vs. 61.2%,  $P > 0.05$ ). A comparison of body fluid status and sodium removal rates of the total study population is shown in Table 2.

According to our target blood pressure values (<135 mmHg for SBP and <85 mmHg for DBP) 17 out of 31 patients (54.8%) were above the target levels at the first visit. The remaining 14 patients were either not hypertensive at all (n: 8) or their blood pressure levels were under control with antihypertensive medications (n: 6). Daily salt consumption, reflected from average TSR values, was calculated as approximately 8 g/day for the total group and 9.1 g/day for the hypertensive PD patient subgroup. When the subgroup of 17 hypertensive patients was taken into consideration, in terms of TSR level there was no significant difference between the 2 visits ( $164.3 \pm 70.9$  mmol/day to  $154.2 \pm 72.3$  mmol/day,  $P$ : NS). However, in addition to SBP, DBP, and TBW values and plasma sodium concentration values the decrease in terms of mean ECW in liters also reached statistical significance in this hypertensive subgroup (see Table 3).

#### 4. Discussion

In the present study, we demonstrated that total body water and blood pressure levels could be reduced significantly by the education of patients about therapeutic compliance, and reducing salt and fluid consumption with monthly dietary consultations. The patients in our study were actually quite resistant to dietary recommendations about salt restriction. However, even a small reduction in daily dietary sodium intake, which was reflected by daily total sodium removal, resulted in a significant reduction in blood pressure levels and fluid overload. Additionally, education about hypervolemia and hypertension alongside dietary recommendations might have influenced patients' compliance in terms of antihypertensive drug use and water consumption, which might have eventually contributed to better blood pressure control.

The prevalence of hypertension in PD patients was reported to be 82% in a single center study and, despite the use of antihypertensive drugs, 73% of them remained having uncontrolled hypertension according to ambulatory blood pressure measurements (13). Another study, from Italy, also reported the prevalence of hypertension at 88% in 504 PD patients (5). In Turkey, according to the data of the renal registry, the prevalence of hypertension was clearly higher in PD patients (57.5%) than in hemodialysis patients (34.9%) (14). Consistent with these data, the frequency of hypertension was 74% among our study population.

**Table 2.** Comparison of body fluid status, blood pressure, sodium removal, and plasma sodium concentrations of the study group (n: 31) between the first and last visits.

	First visit	Last visit	P
ECW (L)	17.5 ± 4.1	17.4 ± 3.7	NS
ECW (%)	24.2 ± 2.3	23.2 ± 3.3	NS
ICW (L)	21.1 ± 6.0	21.0 ± 5.6	NS
ICW (%)	29.2 ± 3.7	28.2 ± 4.4	NS
TBW (L)	39.2 ± 10.9	38.3 ± 9.3	0.04
SBP (mmHg)	134.3 ± 20.1	127.2 ± 19.5	0.01
DBP (mmHg)	83.2 ± 12.0	77.4 ± 10.5	0.01
No. AHM	1.55 ± 1.23	1.48 ± 1.15	NS
USR (mmol/day)	52.7 ± 69.2	49.9 ± 72.1	NS
PSR (mmol/day)	86.8 ± 43.2	86.2 ± 49.7	NS
TSR (mmol/day)	139.4 ± 69.1	136.2 ± 64.8	NS
Na (mmol/L)	137.3 ± 4.4	135.1 ± 3.9	.01
Hematocrit (%)	34.0 ± 6.5	34.9 ± 5.8	NS
Albumin (g/dL)	3.49 ± 0.34	3.52 ± 0.27	NS
Icodextrin usage (%)	67.7% (21/31)	70.9% (22/31)	NS
ESA usage (%)	54.8% (17/31)	61.2% (19/31)	NS

ECW: Extracellular water, ICW: Intracellular water, TBW: Total body water, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, No.AHM: Number of antihypertensive medications, USR: Urinary sodium removal, PSR: Peritoneal sodium removal, TSR: Total sodium removal, Na: Plasma sodium concentration, ESA: Erythropoietin stimulating agent

Despite the multifactorial nature of hypertension, volume overload clearly has the major role in PD patients (15,16). Earlier studies have reported good volume and blood pressure control in early periods of PD therapy; but they also pointed out that the progressive loss of residual renal function in following years could induce hypervolemia and hypertension in these patients (17,18). Even though hypervolemia is generally accepted as a result of inadequate fluid removal in PD patients, a recent study showed that hypertensive PD patients had a higher fluid and sodium removal compared to normotensive ones and the authors stressed the role of sodium intake along with inadequate fluid removal in hypervolemia (19). Accordingly, reduced salt intake was found to be associated with a decline in blood pressure levels in PD patients (20). Gunal et al. put their patients on a strict salt restriction and stopped all antihypertensive treatments in 78 PD patients and showed significantly reduced body weight and blood pressure levels (6). In the present study, in addition to demonstration of decreased blood pressure levels, a decrease in total body water was also demonstrated with salt restriction.

Since fluid and salt removal usually reflect their amount of intake, higher fluid and salt removal likely mean that too much is ingested by the patients. Restricting fluid and salt intake is suggested as the safest strategy to maintain good fluid balance, which may decrease the dialysis dose and the need for hypertonic solutions, as well as blood pressure levels. However, according to our clinical practice, patients with a longer duration of therapy seem to be more resistant to dietary modifications.

The daily intake of sodium has been recommended as less than 2.3 g/day (approximately 5.5 g/day salt) by European Best Practice Guidelines at the initiation of PD treatment (11). However, the SALTURK study showed that daily salt consumption was approximately 18 g/day (daily urinary sodium excretion was  $308.3 \pm 143.1$  mmol/day) in the general Turkish population (21). In a recent study from Turkey on 373 chronic kidney disease patients from stages 1–5, average daily salt intake was reported as nearly 10 g/day (22). In spite of strict dietary consultations, our results were not very different. Average TSR, which reflects daily salt consumption, was calculated as approximately 8 g/day

**Table 3.** Comparison of body fluid status, blood pressure, sodium removal, and plasma sodium concentrations of the hypertensive patients (n: 17) subgroup between the first and last visits.

	First visit	Last visit	P
ECW (L)	19.0 ± 4.4	18.3 ± 3.5	0.04
ECW (%)	24.4 ± 2.5	23.8 ± 2.7	NS
ICW (L)	22.8 ± 6.5	22.5 ± 6.2	NS
ICW (%)	24.4 ± 2.5	23.8 ± 2.7	NS
TBW (L)	44.2 ± 12.3	42.8 ± 10.7	0.05
SBP (mmHg)	150.0 ± 9.5	142.1 ± 11.2	0.01
DBP (mmHg)	92.1 ± 6.1	85.0 ± 5.6	0.01
No. AHM	2.3 ± 0.9	2.2 ± 0.8	NS
USR (mmol/day)	67.1 ± 84.4	63.2 ± 89.5	NS
PSR (mmol/day)	97.2 ± 41.4	91.0 ± 48.9	NS
TSR (mmol/day)	164.3 ± 70.9	154.2 ± 72.3	NS
Na (mmol/L)	136.4 ± 3.9	134.0 ± 3.7	0.03
Icodextrin usage (%)	76.5% (13/17)	82.4% (14/17)	NS
ESA usage (%)	64.7% (11/17)	64.7% (11/17)	NS

ECW: Extracellular water, ICW: Intracellular water, TBW: Total body water, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, No.AHM: Number of antihypertensive medications, USR: Urinary sodium removal, PSR: Peritoneal sodium removal, TSR: Total sodium removal, Na: Plasma sodium concentration, ESA: Erythropoietin stimulating agent

for the total group and 9.1 g/day for the hypertensive PD patient subgroup.

On the other hand, Dong et al. demonstrated that very low sodium intake is accompanied by deficient protein and energy intake, which is found to be related to increased mortality in PD patients. In this study, the average daily salt consumption was 1.41 g/day for low salt consumers and 2.47 g/day for high salt consumers (23). Obviously, daily salt consumption of those patients was much lower than our patients' daily salt intake. This study suggests avoiding malnutrition while targeting strict salt restriction.

There are some limitations of our study. Firstly, although it was a prospective study, the follow-up time was

somewhat short and the sample size was small. Secondly, we were unable to persuade all patients to restrict salt intake as we had planned. It is likely that the changes in the adherence also contributed to the decreased blood pressure levels.

In conclusion, we want to underline that patients' education about hypertension, hypervolemia, and reduction of salt intake should be the main goals in the therapy of patients with PD, in order to decrease cardiovascular morbidity and mortality associated with hypertension.

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