THE RELATION BETWEEN VOLUME LOAD AND BLOOD PRESSURE IN HEMODIALYSIS PATIENTS

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Aim: To investigate the effect of hemodialysis on blood pressure by monitoring ambulatory blood pressure during the interdialysis period and to evaluate the relationship between hypertension and the percentage of total body water calculated via bioelectrical impedance analysis.

Methods: Twenty five patients with end stage renal disease who were in the hemodialysis program were included in the study. But only fifteen patients had been able to stay in the required criteria till the end. Pre- and post-dialysis blood pressures of the patients were measured manually and ambulatory blood pressure measurements were obtained during the interdialysis period. Measurements of total body water were performed with bioelectrical impedance method following the hemodialysis procedure. The patients were evaluated for daily course of blood pressure, use of anti-hypertensive medications, incidence of the falling rate of blood pressure at night, amount of total body water and interdialysis weight gain.

Results: Manual pre- and post-dialysis measurements and mean values of 44 hours' ambulatory blood pressure monitoring were found to be similar. Blood pressures were found to be significantly low until the 24th hour and they were increased at the 2nd day, then returned to initial levels at the 44th hour. There was uncontrolled hypertension in 7 of the 11 hypertensive patients (63.6 %). Mean percentage of total body water was higher in patients with hypertension (61.1 ±9.8 vs. 57.9±7.0, $p>0.05$).

Conclusion: In our study, the reducing effect of hemodialysis on blood pressure was observed and this effect has continued nearly 24 hours after the dialysis. The fact that total body water is more in hypertensive patients supports the idea that volume excess is an important factor responsible from hypertension.

Key words: bioelectrical impedance, hemodialysis, blood pressure.

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INTRODUCTION

The most important causes of mortality in hemodialysis patients are cardiovascular diseases. Among them hypertension is in the first line; 60-80 % of hemodialysis patients are hypertensive (1-3). Thus, controlling blood pressure is the first therapeutic target for these patients. Many authors emphasize the need for prospective studies that will be employed with advanced methods of blood pressure measurement in order to develop a protocol for optimal treatment of hypertension in patients with high risks (4, 5).

Ambulatory blood pressure monitoring (ABPM) was recently brought to routine use. It provides non-invasive and automatic measurement of blood pressure during one or more days without affecting daily activity of the patient (6). The superiority of this technique versus manual measurements is provision of more frequent and reliable measurements. The opportunity of blood pressure measuring during sleep is another advantage of the method. According to Joint National Committee-7 (JNC-7), the correlation between mean ABPM levels or burdensome effect of blood pressure and end organ damage was more obvious than office measurements (7). So, ABPM is a useful instrument for clinical and investigational aims. But it is expensive and necessitates training the patient.

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Bioelectrical Impedance Analysis (BIA) is a method that may measure water content and components of the body and is developed in last decade. Variable numbers of electrodes are kept in touch with different parts of the body and volumes of total body water (TBW), extracellular and intracellular fluids may be measured non-invasively on physical basis. Its employability in end stage renal disease and hemodialysis patients was shown in a few studies (8, 9). It may provide useful information in determining dry weight, required quantity of ultrafiltration and volume of urea distribution (10, 11). Despite its easy applicability and provision of useful information, it is only used for experimental purposes.

We aimed to show the unpleasant effect of volume excess on blood pressure in dialysis patients. We investigated the effect of hemodialysis on blood pressure by ABPM during the interdialysis period and evaluated the relationship between hypertension and percentage of total body water (TBW %) that was calculated via BIA.

MATERIAL AND METHODS

Twenty five patients with end stage renal disease who were in the hemodialysis program at the Ministry of Health, Ankara Training and Investigation Hospital, Hemodialysis Unit were included in the study. The patients who are older than 18 years, who are having hemodialysis for at least 3 months and whose serum intact parathormon (iPTH) and hematocrite levels and calcium phosphorus multiply levels are in normal limits and who are getting erythropoietin in continuing doses were included to the study. The ones whose hemodialysis time is less than 3 month were didn't included because they couldn't have got their dry weight yet. Those who had congestive heart failure or edema, who were not able to use ABPM instrument and who were difficult to cooperate were excluded from the study. Ten patients who did not show compliance with ABPM instrument despite adequate training were excluded as well. Eleven males and four females were able to complete the study in accordance with desired criteria. All participants were informed about the study and their informed consents were obtained.

The participants were receiving hemodialysis sessions with bicarbonate for three times a week and for four hours. The procedures were performed in the morning or afternoon sessions. Hollow fibers, polysulphane dialysers with a surface area of $1m^2$ were used. The patients' 24 hour urine volume was less than 500 ml. All the patients were having a diet that was including 2 gr Na and 1.2 gr/kg protein and this diet was continued at the whole period of the study. Gender, age, reasons for end stage renal disease, durations of hemodialysis, use of antihypertensive medications and weights of the patients were recorded. Post-dialysis body weights were taken into consideration as they reflected dry weight better. The difference between previous (post-hemodialysis) weight and current (pre-dialysis) weight was calculated in order to determine the amount of weight gain during the interdialysis period.

The causes of end stage renal disease were as followings: hypertension (7 patients), amyloidosis (3 patients), diabetes mellitus (2 patients) chronic glomerulonephritis (2 patients) and urinary obstruction (nephrolithiasis, 1 patient).
Manual pre- and post-dialysis blood pressure values were got from the mean of the three measurements performed before dialyse and after dialyse. They were calculated and recorded. The threshold of hypertension diagnosis was accepted as 139/89 mmHg level according to JNC-7 report.

ABPM records of patients were obtained for 44 hours during in the second short interdialytic period with RZ250 ABP Recorder (71-22 Myrde Avenue Glandale, New York 11385). Measurements were performed with intervals of 15 minutes at day time and 30 minutes at night time. The hours between 7 am and 10 pm were accepted as daytime and between 10 pm and 7 am were accepted as night time. The threshold defined in JNC-7 report for ABPM measurements were used for hypertension diagnosis.

Total body water measurements were performed within the first 30 minutes following hemodialysis procedure. Monofrequency and foot-to-foot impedance apparatus (TANITA body composition analyzer TBF-300) was employed. Gender, height, weight and age of the patients were recorded to the apparatus and then the measurements

Table 1. Demographic features of patients

Number of Patients (n)	15
Sex (M/F)	11/4
Age (years)	42.1 ± 14.9
Duration of dialysis (months)	45.4 ± 55.7
KT/V Value (sessions)	1.3 ± 0.2
Diagnosis of Hypertension (n)	11
Use of Antihypertensives (n)	10
Dry weight (kg)	62.2 ± 10.5
TBW (kg)	36.2 ± 6.4
TBW (%)	59.4 ± 8.3
Interdialysis weight gain (kg)	2.7 ± 0.7
Calcium (mg/dl)	8.9 ± 0.6
Phosphor (mg/dl)	4.4 ± 0.7
Calcium X Phosphor	38.9 ± 5.6
Parathormon (pgr/ml)	43.9 ± 5.6
Hematocrit	37.4 ± 1.5

were performed and TBW % values were calculated. Mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) values were calculated from the full data of 44 hours. Also the mean SBP and DBP values were calculated for every four hours' section (0.-4. hr, 4.-8. hr and so on...) to see the progress of the blood pressure.

The patients were estimated for daily course of blood pressure, use of antihypertensive medications, the falling rate of blood pressure at night, percentages of total body fluid, and weight gain between hemodialysis sessions.

Statistical analyses were performed via SPSS software. Chi-square test was employed in order to compare categorical data and Pearson's chi-square test was employed to evaluate the relations between parameters. Regression correlation analysis was used to assess the relation between two variables. The data were expressed as mean ± standard deviation and percentage. The level for statistical significance was considered as $p<0.05$.

RESULTS

Fifteen patients who were appropriate with the characteristics of the study were included. Patient demographics are presented in Table 1. Pre- postdialytic manual values and mean ABPM values of total 44 hours were similar as seen in Table 2. The mean blood pressure values of patients during the 4 hours periods are shown in Table 3.

The number of antihypertensive medications was one in seven patients, two in one patient, three in one patient and four in one patient. According to ABPM recordings, there was hypertension in six of the ten patients (60%) who were using antihypertensive medications.

There was uncontrolled hypertension in seven of eleven hypertensive patients (63.6%) who were included in the study.

Only two of 15 patients (13.3%) who were included were determined to be dippers. Blood pressures of five patients (33.3%) were higher during nights than daytime (reverse dipping).

There was not any difference of weight gain between hemodialysis sessions in patients who were and were not found to be hypertensive with ABPM recordings (2.7±0.8 kg and 2.7±0.6 kg, respectively) ($p>0.05$).

Mean TBW % was 61.1±9.8 in seven patients who were determined to be hypertensive and 57.9±7.0 in others who were not hypertensive ($p>0.05$). There was not any correlation between TBW % and ABPM measurements.

DISCUSSION

Controlling hypertension is the most important therapeutic option in decreasing morbidity and mortality in patients with end stage renal disease. This conclusion was shown in many long

Table 2. Comparison of ABPM and manual measurements in hemodialysis patients.

Measurements, mmHg	Pre-dialysis Manual	Post-dialysis Manual	ABPM 44 Hours	p
Systolic	135.7 ± 22.0	133.2 ± 23.8	129.8 ± 18.7	>0.05
Diastolic	88.0 ± 12.2	85.3 ± 17.0	83.0 ± 13.6	>0.05

lasting studies with large populations. Choosing an early and effective treatment modality is an obligation in controlling hypertension. It is possible to assess the effectiveness of the treatment and even to determine its correlation with target organ damage by using sufficient blood pressure measurements performed with reliable methods. By this way, getting information about the course of blood pressure during 24 hours is also possible that. For this purpose, use of ABPM in patients with end stage renal disease and receiving hemodialysis was considered and found to be possibly reliable in some clinical investigations (12). In our study, we observed that ABPM was ideal to diagnose hypertension and follow the course of blood pressure. Moreover, we found that the effect of hemodialysis on blood pressure continued for 24 hours and this finding was consistent with the results of Elisaf and colleagues (13). Agarwal and colleagues followed 20 patients who were receiving hemodialysis for at least three months with ABPM for 44 hours. They showed that blood pressures decreased progressively after hemodialysis, continued to be low during the nights, returned to pre-dialysis levels in the following mornings and did not decrease again the second nights (14). Battle and colleagues observed decreases in blood pressure in first few hours following hemodialysis. They suggested that these decreases were due to changes in vascular resistance or hypovolemia that was a consequence of intravascular volume shift (15).

Table 3. The means of the blood pressures of the patients, measured at 4 hours' periods

Hours	SBP	DBP
0.-4.	130.2±20.0	84.3±15.5
4.-8.	130.2±23.7	84.3±16.1
8.-12.	127.4±24.3	82.5±16.5
12.-16.	121.0±18.6	78.5±12.0
16.-20.	126.1±17.9	81.4±12.9
20.-24.	132.2±20.7	84.8±16.5
24.-28.	132.1±21.3	82.4±14.8
28.-32.	132.7±18.2	83.0±15.1
32.-36.	131.1±21.3	83.2±13.0
36.-40.	125.4±17.9	79.6±12.0
40.-44.	131.2±18.8	83.6±14.2

SBP: systolic blood pressure, DBP: diastolic blood pressure

We found that blood pressures of patients decreased prominently until the 16th hour during the post-dialysis period (Figure 1.). The lowest SBP and DBP levels were obtained at the 16th hour. The measurements increased to the levels of the 4th hour at the beginning of the second day, showed slight undulations during the second day and returned to initial levels at the end of 44 hours. Maximum measurements were obtained at 32nd hour for systolic and 24th hour for diastolic blood pressure .

It is proposed that volume load is the most important factor in the pathogenesis of hypertension in patients with end stage renal disease. The ability of kidneys of maintaining fluid and salt balance diminishes in patients with chronic renal failure. As a consequence, prominent fluid and electrolyte changes come into the scene. Maybe the most important change is positive fluid balance. It is proposed that positive fluid balance plays an important role in development of hypertension in chronic renal failure. A relationship between hypertension and total exchangeable sodium was shown in early and late stages of renal parenchyma diseases (16-18). Various laboratory or clinical methods were developed and used in order to determine volume load in dialysis patients. Probably the most intensely studied method among them was to measure total, intravascular and extravascular body waters via BIA. It is possible to evaluate volume load precisely and practically with this method (10, 11).

There was limited number of studies that evaluated the relation between hypertension and TBW and the effects of hemodialysis on TBW. Various results were obtained from these studies. These

variances might be due to limited numbers of patients and different characteristics of patient groups (19, 20).

Katarzki and colleagues evaluated 82 patients with normal blood pressures and 41 hypertensive dialysis patients and compared them with normal individuals. They found out that TBW and extracellular fluid volumes were significantly higher in hypertensives than in patients with normal blood pressures. TBW and extracellular fluid volumes decreased after dialysis. As a consequence, BIA was found to be a convenient non-invasive method to determine dry weight (19).

Alvarez and colleagues measured TBW and extracellular fluid volumes of 32 dialysis patients with BIA and found them to be significantly higher in hypertensives when compared to patients with normal blood pressures (20).

There was a common conclusion of all studies that were performed: if control of post-dialysis extracellular fluid volume was adequate, blood pressure could be normalized independently from the duration and dose of hemodialysis. But to provide this requirement in short hemodialysis sessions was not so easy. Moreover there were some endocrine, neurogenic or metabolic factors that effected hypertension independently from extracellular fluid volume.

In our study, TBW percentage of patients who were found to be hypertensive with ABPM was higher than patients with normal blood pressures, but the difference between them was not statistically significant (respectively 61.1±9.8, 57.9±7.0). There was no correlation between TBW % and blood pressure. Additionally, TBW % and the duration of hemodialysis were not related as well. These results were consistent with the literature (19, 20).

As a conclusion; both ABPM and BIA were still investigational tools in hemodialysis patients. As the results of studies that were performed with these methods were controversial, they were not proposed to be used routinely in guidelines. We suggest that there is a need for further large studies.

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