Hemodiyaliz Hastalarında Kardiyak Performans ile Bipedal Biyoimpedans Analiz Verileri Arasındaki İlişki

Relationship Between Bipedal Bioimpedance Analysis Data and Cardiac Performance in Patients on Maintenance Hemodialysis

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ÖZET

Son zamanlarda, total vücut suyunun (TVS) hipertansiyon ve kardiyak morbidite ile ilişkisi nedeniyle hemodiyaliz (HD) hastalarında prognostik önemi olduğu kabul edilmektedir. Bu çalışmanın amacı, HD hastalarında HD seansı öncesi ve sonrasında bipedal biyoelektrik impedans analizi (BP-BİA) ile ölçülen TVS değişiklikleri ve ekokardiyografi ile belirlenen morfolojik ve fonksiyonel kardiyak değişiklikleri değerlendirmektir.

Bu çalışmaya, en az altı aydır düzenli HD tedavisi gören, klinik olarak stabil 20 erişkin HD hastası (13 erkek, 7 kadın; ortalama yaş [yıl]: 60 ± 15.6) alınmıştır. Diyaliz öncesi ve sonrasında TVS hesaplaması için Watson formülü (TVS-W) ve BP-BİA (TVS-BP-BİA) kullandık. Ekokardiyografik ölçümler pre- ve post-diyaliz periyotta yapıldı.

Diyaliz sonrası vücut ağırlığı, TVS-W ve TVS-BP-BİA'da anlamlı düşüş gözlendi. Diyaliz seansı sonrası LVIDD, LVEDV, LVESV, LAD, RAD, SV ve CO ölçümleri belirgin şekilde düşüş gösterdi. Ejeksiyon fraksiyonu ve kalp hızında HD sonrasında anlamlı değişiklik olmadı. Pre- ve post-diyalitik periyotta TVS-BP-BİA değerleri, kalp odacığı çapları ve fonksiyonları ile korelasyon göstermedi.

Normal sol ventrikül fonksiyonlarına sahip, hemodinamik olarak stabil hastalarda, diyaliz sırasında TVS'deki azalma kalp odacıklarının çaplarında küçülmeye neden olmaktadır. BP-BİA TVS ölçümünde kullanılabilen basit bir yöntemdir. Bu çalışmada ayrıca, pre- ve post-diyalitik periyotta kalp odacıkları çaplarında ve TVS-BP-BİA arasında korelasyon gözlenmedi.

Anahtar sözcükler: total vücut suyu, bipedal biyoelektrik impedans analizi, kardiyak performans, hemodiyaliz

ABSTRACT

Total body water (TBW) has recently been recognized as having independent prognostic value in hemodialysis patients because of its relationship with hypertension and cardiac morbidity. The aim of this study is to investigate associations between TBW changes measured by bipedal bioelectrical impedance analysis (BP-BIA), and morphologic and functional cardiac changes assessed by echocardiography in hemodialysis patients before and after the same dialysis session.

Twenty clinically stable adult hemodialysis patients (13 males, 7 females; mean age [years]: 60 ± 15.6) who had been on regular dialysis treatment for at least six months were included in the study. We used BP-BIA and the Watson equations for estimating TBW before and after dialysis sessions. Echocardiographic measurements were performed in pre- and post-dialysis periods.

After dialysis, significant decreases in TBW-BP-BIA, TBW-W and body weight were observed. LVIDD, LVEDV, LVESV, LAD, RAD, SV and CO measurements were markedly decreased after dialysis sessions. Ejection fraction and heart rate did not change significantly after hemodialysis. TBW-BP-BIA values showed no correlation with cardiac chamber diameters and functions in pre- and post-dialytic periods.

In hemodynamically stable patients having normal left ventricular functions, a reduction in TBW during dialysis causes a diminution in the diameter of cardiac chambers. BP-BIA, a simple method, can be used for TBW measurement. In addition, in this study, no correlation was observed between pre- and post-dialytic period cardiac chamber diameters and TBW-BP-BIA.

Keywords: total body water, bipedal bioelectrical impedance analysis, cardiac performance, hemodialysis

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Introduction

In hemodialysis therapy, Kt/V (K [clearances], t [time] and V [the volume of distribution of urea]) determine dialytic adequacy by the formulae derived using estimated dry body weight as a marker of V.

Since urea is distributed uniformly into the body water, the estimated V is equal to the total body water (TBW) (1). Additionally, TBW has recently been recognized as having independent prognostic value in hemodialysis patients because of its relationship with hypertension and cardiac morbidity (2,3). Bipedal bioimpedance analysis (BP-BIA) is a simple method for the determination of TBW at the same time as the patient is weighed (4). BIA can be useful for estimating body hydration, for prescribing fluid removal, and for monitoring fluid changes during hemodialysis (5). The effect of hemodialysis on cardiac performance is variable. These effects depend on factors such as fluid status, blood pH, the kind of dialysate, and calcium homeostasis. There have been several echocardiographic studies of morphological and functional pre- and post-dialytic cardiac changes in end-stage renal disease (ESRD) patients on maintenance hemodialysis (6-9).

The aim of this study was to investigate associations between TBW changes measured by BP-BIA (TBW-BP-BIA), and morphologic and functional cardiac changes assessed by echocardiography in hemodialysis patients before and after the same dialysis session.

Patients and Methods

Patients: Twenty clinically stable, anuric adult hemodialysis patients (13 males, 7 females; mean age [years]: 60 ± 15.6) who had been on regular dialysis treatment for at least six months were included in the study. The patients had been on hemodialysis (HD) for 48 ± 42 months. All patients received conventional dialysis for 4 h, three times a week, with dialysate sodium of 140 mEq/L, bicarbonate buffer, blood flow of 300 mL/min, and a dialysate flow of 500 mL/min. Ultrafiltration was under strict control, and an ideal dry weight was presumed to have been achieved when intolerance became evident through muscle cramps or hypotensive episodes. We included clinically stable patients with no hospitalization in the month prior to the beginning of the study, who were normotensive without antihypertensive drugs, and without limb amputation. Criteria for exclusion were severe heart failure (New York Heart Association class III-IV), valvular and/or congenital heart disease, known ischemic heart disease and cardiomyopathy. Hypertension was defined as a pre-dialysis systolic blood pressure >140 mmHg or diastolic >90 mmHg or mean arterial pressure (MAP) >107 mmHg.

Blood pressure (BP) was measured with an aneroid sphygmomanometer (Erka, Bad Tölz, Germany). Pre- and post-dialytic BPs (the mean value of a total of 3 measurements in 15 min) measured by the same nurse were recorded. MAP was calculated using the conventional formula (MAP [mmHg] = Diastolic BP [mmHg] + (Systolic BP [mmHg] - Diastolic BP [mmHg]) / 3).

Bioimpedance measurements: BIA was performed with the patient in a standing position according to “foot to foot” pressure contact electrode techniques using a low energy, single frequency (50 kHz, 500 mA) analyzer (Tanita Body Composition Analyser, Tokyo, Japan). We performed bioimpedance measurements 30 min before and after mid-week HD sessions. TBW, impedance, body weight, and body mass index (BMI) were calculated by equations in the BIA software.

We used also the Watson equations for estimating TBW (TBW-W). TBW-W was calculated before and after dialysis session as follows:

(Men) V = 2.447 - 0.09516 (age) + 0.1074 (height) + 0.3362 (weight)

(Women) V = - 2.097 + 0.1069 (height) + 0.2466 (weight)

where V (volume) is in liters, age is in years, height is in centimeters, and weight is in kilograms.

Echocardiography: Echocardiograms were obtained using a Wingmed System 5 (Norway). All measurements were taken according to American Society of Echocardiography criteria by the same cardiologist who was blinded. We measured left ventricular internal diastolic diameter (LVIDD), left ventricular internal systolic diameter (LVISD), left ventricular end-diastolic volume (LVEDV), left ventricular end-systolic volume (LVESV), left atrial diameter (LAD), right atrial diameter (RAD), stroke volume (SV), cardiac output (CO), and ejection fraction (EF). Echocardiographic measurements were performed simultaneously with BIA, pre- and post-dialysis.

Statistical analysis: Statistical analysis was performed on a PC with the statistical analysis software “SPSS 11 for Windows”. Results were expressed as means ± SD. The Wilcoxon signed ranks test was used to investigate differences between pre- and post-hemodialysis parameter values. Correlation between pre- and post-dialysis measurements was described using Kendall’s tau-b coefficient (r). A probability value of $p < 0.05$ was taken as significant.

Table I. Demographic and clinical features of the patients	
Features	**Value**
Total no. of patients	20
Men	13
Women	7
Age (years)	60 ± 15.6
Duration of hemodialysis (months)	48 ± 42
Percentage of ultrafiltration (%)	4.2 ± 2
Interdialytic weight gain (kg)	2.3 ± 1.2

Results

The demographic and clinical characteristics of the patients enrolled in the study are summarized in Table I. Body weight decreased by 2.3±1.2 kg (-4.2±2% of pre-dialysis period) during hemodialysis. After dialysis significant decreases in TBW-BIA, TBW-W and body weight were observed. LVIDD, LVEDV, LVESV, LAD, RAD, SV and CO measurements were markedly decreased after dialysis sessions. Ejection fraction and heart rate did not change significantly after hemodialysis. Compared to those of the pre-dialytic period the MAP values decreased in the post-dialytic period ($p < 0.05$) (Table II).

TBW-BP-BIA values showed no correlation with cardiac chamber diameters and functions in pre- and post-dialytic periods.

The linear correlation between TBW-BIA and TBW-W was highly significant before and after dialysis sessions ($r = 0.95$, $p < 0.001$ and $r = 0.94$, $p < 0.001$, respectively)

Discussion

The most important factors predisposing to abnormal cardiac performance and morphology in hemodialysis patients are volume overload, arterio-venous fistula, anemia and metabolic factors (acidosis, hypoxia, hypocalcemia, and high levels of parathyroid hormone) (9). Various methods are used for the determination of dialysis patient volume status, such as blood pressure measurements, biochemical markers (atrial natriuretic peptide, cyclic guanidine monophosphate), vena cava diameter, blood volume monitoring, Watson's formula and single- or multifrequency BIA, though the number of studies with BP-BIA is low. We investigated the associations between TBW changes measured by two different methods (BP-BIA and Watson's formula), and morphological and functional cardiac changes assessed by echocardiography in hemodialysis patients before and after the same dialysis session.

Hung et al reported that left ventricular (LV) EF did not change in patients with normal pre-hemodi-

Table II. Comparison of pre- and post-dialytic values			
Parameter	**Pre-dialysis**	**Post-dialysis**	**P value**
Weight (kg)	58 ± 12	55.6 ± 11.7	< 0.001
BMI (kg/m^2)	22.5 ± 3.3	21.5 ± 3.8	= 0.001
Impedance (ohms)	499.3 ± 110.1	596 ± 136	< 0.001
TBW-BIA (liter)	33.9 ± 6	32 ± 5.6	< 0.001
TBW-W (liter)	32.0 ± 5.1	31.2 ± 4.9	< 0.001
LVIDD (mm)	52.1 ± 5.4	47.6 ± 5.1	< 0.001
LVISD (mm)	33 ± 5.7	32 ± 4.3	> 0.05
LVEDV (mL)	130.9 ± 32.2	111.3 ± 30.4	< 0.001
LVESV (ml)	43.8 ± 15.8	39.2 ± 14.8	< 0.05
LAD (mm)	37.5 ± 8.1	34.6 ± 7.7	= 0.001
RAD (mm)	37.6 ± 8.8	33.8 ± 6.9	< 0.05
MAP (mmHg)	90.6 ± 6.3	82.7 ± 4.5	< 0.05
Heart rate (bpm)	80,76±15,14	80,47±13,20	> 0.05
Stroke volume (mL)	80,23±14,76	68,19±21,09	< 0.05
Cardiac output (L/min)	6,18±1,01	4,97±1,62	< 0.05
Ejection fraction (%)	65,71±5,23	62,76±5,23	> 0.05

alysis LV EF (10). Nixon et al suggested that hemodialysis produced an improvement in left ventricular contractility that could be dissociated from alterations in loading conditions (11). In our study we observed a statistically significant decrease in TBW levels measured by BP-BIA and Watson equations. In addition, a similar decrease was observed in cardiac chamber diameter (LVIDD, LVESV, LVEDV, LAD and RAD measurements in comparison to the predialytic period) and in SV and CO. However, pre-dialytic LV EF and heart rate measurements did not change significantly in the post-dialytic period. We concluded that in this patient group stable cardiac and hemodynamic profile EF and heart rate did not change, probably due to cardiac contractility being sufficiently good. In the patients in whom ultrafiltration equal to interdialytic body weight increase (2.3 ± 1.2 kg) was applied, MAP values decreased in the post-dialytic period ($p<0.05$).

No correlation was observed between pre- and post-dialysis TBW-BP-BIA and TBW-W values and cardiac chamber diameter and cardiac functions. This finding may well be linked to the cardiac status of the patients included in the study being stable and to fluid loss during ultrafiltration being not only from plasma, but at the same time from the interstitial and intracellular compartments. Jaffrin et al reported that ultrafiltration volume consisted on average of 18% from plasma, 28% from interstitial and 54% from intracellular compartments (12). Koga et al showed that hemodialysis-mediated preload reduction resulted in a non-significant change in left ventricular end-diastolic dimension (LVDd), left ventricular end-systolic dimension (LVDs), LVEDV, LVESV, SV, CO, EF and fractional shortening (13). Nand et al found significant post-dialytic improvements in left ventricular functions in patients with and without fluid overload. They stated that it would be an incomplete explanation to attribute the improvement of the left ventricular functions to fluid overload (6). Trovato et al stated that body weight and TBW had no relationship with echocardiographic alterations and that there was no correlation between ECW and LVESV (7).

It is clear that there is a significant variation in TBW estimation in dialysis patients, depending on the method of calculation applied. In dialysis patients, TBW has most commonly been estimated using 58% of total body weight or the Watson formulae (1,14,15). Isotopic dilution techniques such as deuterium oxide (D_2O) and sodium bromide (NaBr), the gold standard in TBW estimation, are not easily applicable to the clinical setting. In this study, we did not use isotopic dilution techniques. BIA is a technique employed to evaluate both the nutritional and hydration status of dialysis patients. BIA is also used in the determination of relative volume changes occurring during dialysis (7,14,16-18). However, the number of experiments on the subject of the use of BP-BIA in the determination of volume changes in hemodialysis is limited. We sought to compare the results of the changes in TBW occurring in hemodialysis patients during dialysis using BP-BIA and the Watson formula, and to reveal the relation with cardiac performance. Nunez et al reported that impedance measurements and body composition analysis results in healthy individuals were similar to the results obtained with conventional arm-to-leg gel electrode BIA (19).

TBW measurement in hemodialysis patients using the BP-BIA method: Kushner et al showed that BP-BIA reproducibly estimates volume with a lower coefficient of variation than urea kinetic volume. In addition, they reported that TBW measurements performed with BP-BIA showed a correlation with the Watson formula and that this could be used in dialysis units (4). The reason for our preference for the BP-BIA technique to measure TBW rather than segmental bioimpedance analysis, a complicated technique, is that it possesses such advantages as being simple and easy to perform and reproducible, does not require expert personnel, and can even be performed at home.

In this study, TBW-BP-BIA showed a linear correlation with TBW-W in hemodialysis patients. In addition, no significant correlation was observed between pre- and post-dialytic TBW-BP-BIA measurements and cardiac functions and cardiac chamber diameters.

In conclusion, the changes in TBW in hemodynamically stable hemodialysis patients during hemodialysis can easily be identified using BP-BIA. Furthermore, there is a need for studies including larger numbers of patients in order to reveal the correlation between TBW and BP-BIA.

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