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Original Research Article

Evaluation of fluid status related parameters in hemodialysis and peritoneal dialysis patients: Clinical usefulness of bioimpedance analysis

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ABSTRACT

Background and objective: Fluid overload is a common and serious problem that leads to severe complications in dialysis patients. We aimed to compare hydration status as measured with bioimpedance analysis (BIA) method in hemodialysis (HD) and peritoneal dialysis (PD) patients, as well as investigating the association between blood pressure, left ventricular mass index (LVMI) and hydration status.

Materials and methods: We examined 43 HD and 33 PD patients. Blood pressure was recorded. In each group, echocardiographic examinations were performed on all patients. Hydration status was assessed using multifrequency bioelectrical impedance analysis. Overhydration was defined as an overhydration (OH)/extracellular water (ECW) ratio of >0.15.

Results: The OH/ECW ratio was significantly higher in PD patients compared to post-HD patients. Overhydration was statistically more frequent in PD than in post-HD patients (30.3% vs. 11.6%, $P = 0.043$). Systolic blood pressure (SBP) in both post-HD and PD groups, and LVMI in the PD group were found to be significantly higher in overhydrated patients than non-overhydrated patients. In multiple linear regression analyses, increased OH/ECW ratio was independently associated with higher SBP and LVMI.

Conclusions: Fluid overload may be an even more prevalent and serious problem in PD patients. Overhydration is closely associated with increased blood pressure and LVMI. OH/ECW ratio, a derived parameter of fluid load measured by BIA, was a significant and independent determinant of SBP and LVMI.

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1. Introduction

Fluid overload is a common and serious problem that leads to severe complications in hemodialysis (HD) and peritoneal dialysis (PD) patients. Cardiovascular diseases (CVD) are the leading cause of morbidity and mortality in end-stage renal disease (ESRD) patients [1]. Volume and pressure overload have an important impact on development of cardiovascular disease. It is known that fluid overload is clearly associated with hypertension and left ventricular hypertrophy in this population. However, management of hypertension is difficult in dialysis patients, and many patients also have uncontrolled hypertension despite the use of antihypertensive drugs [2]. Moreover, better control of blood pressure requires accurate fluid balance in most dialysis patients.

In addition, it is also shown that fluid overload is associated independently and significantly with mortality in dialysis patients [3,4]. Euvolemia is most commonly evaluated based on unreliable clinical signs, such as changes in body weight, edema and blood pressure, in daily clinical practice by the dialysis provider, but those may lead to misinterpretations. Therefore, more reliable, practical and objective methods are extremely needed. In this respect, bioelectrical impedance analysis (BIA) has been proposed for the assessment of hydration status parameters.

BIA is a simple, safe, novel, rapid, noninvasive and promising method that can be used to determine hydration status in patients on dialysis therapy [5–8]. BIA method has gained increasing popularity in recent years. Different from other methods, it allows quantification of intracellular and extracellular volumes [9]. The Body Composition Monitor (BCM, Fresenius Medical Care, Germany) is a bio-impedance spectroscopy device and has been well validated by gold standard methods for clinical use [5,6].

In the present study, we aimed to compare hydration status, as measured with BIA method, in HD and PD patients in a single center, as well as investigating the association between blood pressure, left ventricular mass index (LVMI) and hydration status.

2. Materials and methods

2.1. Patients

This cross-sectional study design included 43 stable chronic hemodialysis and 33 stable chronic ambulatory peritoneal dialysis (CAPD) patients treated and followed up in the same center. The Local Human Research Ethics Committee approved the study protocol, and informed consent was obtained from all patients at the time of study enrollment.

The exclusion criteria were as follows: (1) patients with ejection fraction <55%, (2) hemodynamically unstable patients, (3) patients who had limb amputation, pacemakers, or metallic intravascular devices, or any malignant disease or pregnancy, (4) patients who had been receiving diuretic treatment.

The HD patients received dialysis 3 times/week, using 1.6 m^2 surface area high-flux polysulphone dialyzers (Fresenius, Bad Homberg, Germany) and bicarbonate-based dialysate (glucose 1 mmol/L, Na^+ 140 mEq/L, HCO_3^- 32 mEq/L, K^+ 2.0 mEq/L, Ca^{2+} 1.25 mmol/L, Mg^{2+} 0.5 mEq/L). Of the 33 patients on CAPD, icodextrin was administered in 65% of them.

Patients' demographics were obtained from both the patients' registries and the patients themselves.

2.2. Measurements

24-h urine samples were collected to determine urine volume. Weight was measured after dialysis. Body mass index (BMI) was calculated as the ratio weight/height^2 (kg/m^2) and body surface area (BSA) was calculated from weight and height.

Systolic (SBP) and diastolic blood pressures (DBP) were measured 30 min after the end of hemodialysis using an air manometer at the time of BIA investigation and are presented as three consecutive measurements taken at 5-min intervals. Blood pressures were measured in PD patients with empty abdomen using the same method.

Blood samples were collected from all patients for biochemical and hematological parameters on the same day as the BIA measurements.

2D-guided M-mode echocardiography (Vivid 7, GE Healthcare, Horten, Norway) with a 3.5 MHz transducer was performed with empty abdomen in all PD patients, and after the hemodialysis session in all HD patients, by the same cardiologist according to the recommendation of the American Society of Echocardiography on the same day as the BIA examination [10]. Left ventricular systolic function was assessed by left ventricular ejection fraction (LVEF). Left ventricle internal diastolic diameter (LViDD), diastolic posterior wall thickness (PWT) and interventricular septum thickness (IVS) were measured. Left ventricular mass (LVM) was calculated using the equation described by Devereux [11].

$$LVM = 1.04 \times [(LviDD + PWT + IVS)^3 - LviDD^3] - 13.6\,g$$

sLVM index (LVMI) was calculated by dividing LVM by BSA.

A multifrequency BIA device (Body Composition Monitor, BCM, Fresenius Medical Care D GmbH), which measures 50 different frequencies from 5 to 1000 kHz, was used to assess hydration status. All measurements were performed by the same operator. BIA was performed with empty abdomen in PD patients, and 30 min after the midweek dialysis session in HD patients. The following parameters were obtained: overhydration (OH), extracellular water (ECW), intracellular water (ICW), total body water (TBW) in liters (L), ECW/TBW, ECW/ICW, and OH/ECW ratio. We used OH/ECW ratio as an indicator of fluid status. Overhydration was defined as an OH/ECW ratio greater than 0.15 according to previous reports [3,12]. Patients were divided into two groups: overhydrated (OH/ECW >0.15) and nonoverhydrated (OH/ECW ≤0.15).

2.3. Statistical analysis

Data analyses were performed using Statistical Package for Social Sciences (SPSS), Version 18.0 for Windows (SPSS Inc., Chicago, IL, USA). Normally distributed variables are presented using means and standard deviations. The Student *t* test was used to compare the means of the continuous variables with normal distribution for related and independent samples. The proportions of patients with overhydration are presented