Kidney Res Clin Pract 34 (2015) 212–218

Kidney Research and Clinical Practice

journal homepage: http://www.krcp-ksn.com
Contents lists available at ScienceDirect

Original Article

Overhydration measured by bioimpedance analysis and the survival of patients on maintenance hemodialysis: a single-center study

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Article history:
Received 26 June 2015
Received in revised form
15 September 2015
Accepted 6 October 2015
Available online 11 November 2015

Keywords:
Bioimpedance analysis
Extracellular water
Hemodialysis
Hydration
Mortality

Abstract

Background: Bioimpedance analysis (BIA) helps measuring the constituents of the body noninvasively. Prior studies suggest that BIA-guided fluid assessment helps to predict survival in dialysis patients. We aimed to evaluate the clinical usefulness of BIA for predicting the survival rate of hemodialysis patients in Korea.
Methods: We conducted a single-center retrospective study. All patients were diagnosed with end-stage renal disorder and started maintenance hemodialysis between June 2009 and April 2014. BIA was performed within the 1st week from the start of hemodialysis. The patients were classified into 2 groups based on volume status measured by the body composition monitor (BCM; Fresenius): an overhydrated group [OG; overhydration/extracellular water (OH/ECW) >15%] and a nonoverhydrated group (NOG; OH/ECW ≤15%).
Results: A total of 344 patients met the inclusion criteria. Of these, 252 patients (73.3%) were categorized into the OG and 92 patients (26.7%) into the NOG. Age- and sex-matching patients were selected with a rate of 2:1. Finally, 160 overhydrated patients and 80 nonoverhydrated patients were analyzed. Initial levels of hemoglobin and serum albumin were significantly lower in the OG. During follow-up, 43 patients from the OG and 7 patients from the NOG died (median follow-up duration, 24.0 months). The multivariate-adjusted all-cause mortality was significantly increased in the OG (odds ratio, 2.569; $P = 0.033$) and older patients (odds ratio, 1.072/y; $P < 0.001$). No significant difference of all-cause or disease-specific admission rate was observed between the 2 groups.
Conclusion: The ratio of OH/ECW volume measured with body composition monitor is related to the overall survival of end-stage renal disorder patients who started maintenance hemodialysis.

Introduction

Modern medicine has evolved in the direction of developing less-invasive methods for a wide variety of diagnoses and treatments. The bioimpedance analysis (BIA) method has been used as a method to measure the constituents of the human

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http://dx.doi.org/10.1016/j.krcp.2015.10.006

body noninvasively. Commercial medical devices using BIA have become popular because of their convenience and safety [1]. It is possible to measure segmental human body composition of water, muscle and fat mass, and even cardiac output using BIA [2–4].

Assessing the precise body water status in patients with renal disorders is very important for their health. It has been reported that chronic fluid overload is present even in the early stages of renal insufficiency [5]. If the volume overload in a patient with chronic renal failure is not controlled, serious problems such as pulmonary edema, cardiac remodeling, and diastolic heart failure can develop [6].

Especially for dialysis patients, an assessment of the dry weight is essential to determine ultrafiltration volume during the dialysis session. It affects both hemodynamic stability and symptoms of the patient, such as muscle cramps, abdominal pain, generalized weakness, dyspnea, edema, hypertension, or hypotension during and after dialysis [7,8]. Clinicians have used predialysis and postdialysis blood pressure (BP), amount of weight gain between dialysis sessions, and subjective symptoms of the patient as an index of volume overload. Recently, an increasing number of dialysis centers have started to use body water measurement devices using BIA.

Prior studies suggest that BIA-guided fluid assessment can help to predict survival rate in dialysis patients. Chazot et al [9] have reported that a hyperhydrated group showed higher all-cause mortality than a nonhyperhydrated group when they were classified according to the ratio of overhydration/extracellular water (OH/ECW) measured with multifrequency whole-body bioimpedance spectroscopy. Fluid overload is thought to be an independent risk factor of all-cause mortality or cardiovascular morbidity in patients with advanced chronic kidney disease (CKD) [10].

According to the report of the Korean Society of Nephrology, the total number of end-stage renal disorder (ESRD) patients was 75,042 and 52,378 patients were undergoing hemodialysis at the end of 2013. The number of new patients undergoing renal replacement therapy was 12,183 which included 9,543 hemodialysis patients in 2013 [11].

To date, there has been no report of survival data for Korean patients according to the volume status measured by the BIA method. We have used the body composition monitor (BCM; Fresenius Medical Care, Bad Homburg, Germany) in a dialysis center since 2009, and the hydration status measured by BCM was correlated well with interdialysis weight gain in our previous cross-sectional study [12]. Because the BCM provides overhydration index and suggested dry weight compared with the reference group, it is easy to understand and apply to the patient at the bedside [1].

The objective of this study was to evaluate the clinical usefulness of hydration status measured by BCM at the initiation of hemodialysis in patients with ESRD for predicting outcomes of dialysis patients. We analyzed the survival and admission rates of each chronic hemodialysis patient, according to hydration status measured by BCM.

Methods

Study design

We conducted a single-center retrospective study of dialysis patients between June 2009 and April 2014. Most data were collected from the electronic medical records of the Chungnam National University Hospital. Information on mortality was obtained from the database of the National Health Insurance Service. We did not give physicians special treatment guidelines depending on hydration status; treatment of each patient was carried out according to the clinical judgment of the attending physician.

Patient selection

All patients were diagnosed with ESRD and started maintenance hemodialysis between June 2009 and April 2014. Maintenance hemodialysis was defined as hemodialysis performed 1–3 times/wk for more than 3 months. BIA was performed within the 1st week from the start of hemodialysis.

Exclusion criteria were as follows: a patient who started dialysis due to acute kidney injury; a patient whose date of dialysis start and death were in the same admission period; and a patient with a history of renal transplantation, a history of peritoneal dialysis longer than 1 month, or active malignancy (all solid organ cancer and hematologic malignancy). Patients were included if the cancer had completely recovered without recurrence for more than 5 years before the start day of dialysis.

Study population

Ultimately, 344 patients met the inclusion criteria. Of these, 252 patients (73.3%) were categorized into the overhydrated group (OG) and 92 patients (26.7%) were assigned to the nonoverhydrated group (NOG). There was a significant difference of mean age between the 2 groups in the preliminary analysis (62.3 years in the OG and 64.4 years in the NOG). Twelve patients who were considered to be dehydrated (OH/ECW $\leq -13\%$) were excluded from our analysis, and age- and sex-matching patients were selected with the rate of 2:1; finally, 160 overhydrated patients and 80 nonoverhydrated patients were analyzed.

Measurements of clinical parameters

Extent of overhydration and dry body weight were assessed with the BCM. The value of initial overhydration measured with BCM was used without modification, if it was measured on the 1st dialysis day. In the case that analysis with BCM was delayed after the 1st dialysis day, the value of initial overhydration was calculated by the difference between initial body weight and dry body weight measured with BCM.

Based on the ratio of overhydration and extracellular water of initial dialysis, the patients were classified into 2 groups: OG (OH/ECW >15%) and NOG (OH/ECW $\leq$15%). The cutoff value of our study (OH/ECW >15%) was selected with reference to the analysis by Chazot et al [9] and Wizemann et al [13].

Baseline patient characteristics analyzed included age at start day of dialysis (years), sex, height (cm), initial body weight (kg), overhydration (L), dry body weight (kg), initial systolic/diastolic BP (mmHg), initial comorbidities (presence of diabetes, hypertension, glomerulonephritis, cardiovascular disorder, or cerebral vascular disorder), and initial laboratory data [hemoglobin, blood urea nitrogen, creatinine (Cr), albumin, total calcium, phosphorus, sodium, potassium, chloride, C-reactive protein, intact parathyroid hormone (PTH), iron, total iron-binding capacity, transferrin saturation, and ferritin].