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The body fluid monitoring during hemodialysis using bioimpedance techniques in end-stage renal patients

Ocena stanu nawodnienia w czasie zabiegu hemodializy za pomocą techniki bioimpedancji elektrycznej u pacjentów ze schyłkową niewydolnością nerek

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S u m m a r y

End stage kidney disease (ESKD) substantially increases the risks of death and cardiovascular disease (CVD). Uncontrolled status of hydration in HD patients population is associated with the occurrence of arterial hypertension, dialysis associated hypotension and other symptoms and signs including pulmonary and peripheral edema, heart failure, and left ventricular hypertrophy. However, assessment of fluid overload can be difficult in clinical practice. Relative blood volume monitoring, measurement of inferior vena cava diameter by ultrasound and biochemical markers are indirect methods, which do not reflect the ECV and fluid status accurately. There is very important to help us understand the association between clinical practices and hydration and nutritional status, and their effects on dialysis patient outcome.

The bioimpedance spectroscopy techniques are postulate as very useful methods for routinely monitoring of hydration status in hemodialysis population. Both routine clinical appreciation and bioimpedance should be combined in clinical decision-making on hydration status.

S t r e s z c z e n i e

Schyłkowa niewydolność nerek wpływa na istotny wzrost ryzyka zgonu oraz wystąpienia powikłań sercowo-naczyniowych w tej grupie pacjentów. Niekontrolowany stan nawodnienia w populacji pacjentów hemodializowanych jest związany z ryzykiem wystąpienia nadciśnienia tętniczego, hipotonii śróddializacyjnej oraz takich objawów jak: obrzęki, niewydolność krążenia oraz przerost lewej komory mięśnia sercowego. Rutynowa ocena wielkości przewodnienia może stwarzać problemy w codziennej praktyce klinicznej. Monitorowanie stanu relatywnych zmian objętości osocza, ultrasonograficznej oceny żyły próżnej dolnej oraz biochemicznych markerów nie stanowi narzędzi do precyzyjnej oceny wielkości przestrzeni zewnątrzkomórkowej (ECW) oraz stanu nawodnienia. Niezwykle ważnym zagadnieniem w praktyce jest zrozumienie zależności pomiędzy stanem odżywienia a stanem nawodnienia oraz ich wpływu na okres przeżycia pacjentów dializowanych. Technika bioimpedancji elektrycznej jest postulowana do wykorzystania w rutynowej ocenie stanu nawodnienia w populacji pacjentów hemodializowanych. Zarówno rutynowa ocena kliniczna, jak i pomiary bioimpedancyjne stanu nawodnienia powinny służyć podejmowaniu finalnych decyzji terapeutycznych.

INTRODUCTION

Non-euvolaemia in HD patients is associated with elevated mortality risk. Achievement of a normal hydration state is one of the major targets of hemodialysis (HD) therapy. An abnormal hydration state has been associated with arterial hypertension, dialysis associated hypotension and other symptoms and signs include pulmonary and peripheral edema, heart failure, left ventricular hypertrophy and other adverse cardiovascular events. To determine the hydration state clinical surrogate parameters are used such as interdialytic weight gain, ultrafiltration rate or blood pressure. Several authors have reported an important improvement in cardiac conditions by volume optimal monitoring strategy in HD patients. Charra and Chazot (1) and Ozkahya et al. (2) studies have shown that a strict volume control strategy decreases blood pressure (BP) without drugs, causes regression of LVH, and prolongs survival. Kalantar-Zadeh et al. examined 2-year mortality in 34,107 hemodialysis patients across the United States who had an average weight gain of at least 0.5 kg above their end-dialysis dry weight by the time the subsequent hemodialysis treatment started. They concluded, that, the greater fluid retention between 2 subsequent hemodialysis treatment sessions is associated with higher risk of all-cause and cardiovascular death (3).

BIOIMPEDANCE TECHNIQUES FOR ASSESSMENT OF FLUID STATUS IN HEMODIALYSIS POPULATION

Bioimpedance technology is based on passing a bioelectrical current through the body, and it estimates the body fluid volume by the amount of resistance this current endures in the body tissues. The bioelectrical current used in these devices can have segmental, spectral, or multi-bioelectrical frequencies. At present time, available bioimpedance techniques are generally classified using different frequency spectrum: the first option is the single frequency at 50 kHz or other current frequency bioimpedance (BI) analysis (SF-BIA), the multifrequency BI analysis using more than one frequency (e.g., 5, 50, and 100 kHz) and finally multifrequency BI spectroscopy (MF-BIS) using a range of frequencies such as 5 kHz to 1000 kHz to measure extracellular and intracellular resistance by Cole model. Two options for practical measurement of hydration status is based on whole body (wrist to ankle) measurements, or segmental (arm, trunk, and leg) measurements including calf BI spectroscopy (4, 5). The widely useful BIS technique, especially in European dialysis units is the body composition monitor (BCM) is based on a whole-body BI model, which is established with ECV, ICV, and body weight based on parameters from regression analysis in HSs to calculate fluid overload (FO) in dialysis patients. Webel et al. reported usefulness of the model in a clinical study with BCM guiding the reduction of FO in five hundred HD patients to achieve normal blood pressure (6). Raimann et al. compared the study of 49 HD patients of a single and multifrequency-BIA to direct estimation methods using isotope technique of TBW, ECF, and ICF in 49 hemodialysis patients. Comparisons of indirect methods (IEMs) to DEMs showed no significant differences and proportional errors (7).

CLINICAL OBSERVATIONAL STUDIES FOR THE MONITORING OF HYDRATION STATUS IN HEMODIALYSIS PATIENTS USING BIOIMPEDANCE TECHNIQUES

In several clinical observational studies, registry reports and uncontrolled single center studies the association between hydration state and the outcome has been described. However clinical findings are not always conclusive and often contradictory as demonstrated for interdialytic weight gain and hydration state (8, 9).

Wizemann et al. measured the hydration status of 269 prevalent HD patients (28% diabetics, dialysis vintage = 41.2 ± 70 months) in 3 European centers with a Body Composition Monitor (BCM) which enables quantitative assessment of hydration status and body composition. The survival of these patients was estimated after a follow-up period of 3.5 years. The cut-off threshold for the definition of hyperhydration was set to 15% relative to the extracellular water (ECW), which represents an excess of ECW of ca. 2.5 L. The unadjusted gross annual mortality of all patients was 8.5%. The hyper hydrated subgroup (n = 58) presented ∆HSpre = 19.9 ± 5.3% and a gross mortality of 14.7% (10).

In an interesting comparable study of Chazot et al., 50 HD patients treated with 3 x 5-8 h/week from Tassin (Lyon, France) was compared to one dialysis center from Giessen (Germany) treated with 3 x 4-5 h/week, which was separated into a non-hyperhydrated (n = 123) and a hyperhydrated (n = 35) patient group. All-cause mortality was analyzed after a 6.5-year follow-up. The hydration status of the Tassin patients was no different to the non-hyperhydrated Giessen patients but significantly lower than in the hyperhydrated Giessen group. Multivariate adjusted all-cause mortality was significantly increased in the hyperhydrated patient group (hazard ratio; 3.41), but no difference in mortality could be observed between the Tassin and the non-hyperhydrated group from Giessen, even considering the fact that Tassin patients presented a significantly lower blood pressure (11). The intra abdominal pressure is an important risk factor for the outcome of septic shock and acute kidney injury Dabrowski et al. analyzed the effect and the time course of continuous veno-venous hemofiltration (CVVH) with net ultrafiltration (UF) on intra-abdominal pressure (IAP) body fluid volumes in septic shock patients with acute kidney injury (AKI). Patients were studied at baseline and after 6, 12, 24, 48, 72, and 96 hours of CVVH treatment, and intra abdominal pressure (IAP), was measured via the bladder, and abdominal perfusion pressure (APP) was calculated as mean arterial pressure minus IAP. Fluid volume excess (VE), total body water (TBW), extracellular body water (ECW), and intracellular body water (ICW) were derived from whole body bioimpedance analysis (BIA). 30 patients entered final analysis, of which 6 died during CVVH (non-survivors). Fluid VE, TBW, ECW, ICW, and IAP significantly decreased in 24 survivors, whereas these variables remained essentially unchanged in non-survivors. APP slowly increased in survivors, while it did not change in non-survivors. IAP strongly correlated with VE in survivors. An increase in intra-abdominal pressure (IAP) may result from extra-abdominal pathology, such as massive fluid resuscitation, capillary leak or sepsis. In another study Dabrowski et al. indicated, that IAP strongly correlates with ECW in 120 patients treated on dialysis (12, 13).

Hur et al. in prospective, randomized, and controlled study investigated 156 hemodialysis patients dry weight assessment by routine clinical practice and fluid overload was assessed by bioimpedance spectroscopy. The primary outcome was regression of left ventricular mass index during a 1-year follow-up. They concluded, that assessment of fluid overload with bioimpedance spectroscopy provides better management of fluid status, leading to regression of left ventricular mass index, decrease in blood pressure, and improvement in arterial stiffness (14).

In the study of Arneson et al. the authors estimated the magnitude of fluid overload treatment episodes for the Medicare hemodialysis population in hospital settings, including emergency departments. Fluid overload treatment episodes were defined by claims for care in inpatient, hospital observation, or emergency department settings with primary discharge diagnoses of fluid overload, heart failure, or pulmonary edema, and dialysis performed on the day of or after admission. They analyzed 25,291 patients, 41,699 care episodes occurred over a mean follow-up time of 2 years: 86% inpatients, 9% emergency department, and 5% hospital observation. Heart failure was the primary diagnosis in 83% of episodes, fluid overload in 11%, and pulmonary edema in 6%. They concluded, that in U.S. hemodialysis patients' population, fluid overload treatment is common and expensive (15).

CONCLUSIONS

According to the estimation of The Polish Society of Nephrology entitled: "The Recommendations of the Working Group of The Polish Society of Nephrology for the criteria of quality treatment in dialysis patients with end-stage renal disease" has been postulate, that the most important factors for routine estimation of fluid status in hemodialysis population are: interdialytic fluid intake, assessment of bioimpedance parameters such as; ECW, ECW and TBW ratio, overhydration Index (OH%), as measured by bioimpedance technique and lung ultrasonography. The percentage of patient with interdialytic fluid intake, more than 5% of dry weight should be less than 15% of HD population. The percentage of overhydrated patients was measured by BIS OH index should be less than 15%. We recommend such kind of measurements for routinely use for each 6 weeks. We postulate that routine measurement of the echocardiography (left ventricle hypertrophy identification) for at least 12 months for all HD population (16).

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