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Changes of extracellular volumes measured by whole and segmental bioimpedance analysis during hemodialysis in end-stage renal disease (ESRD) patients

The precise estimation of body composition and hydration plays an important role in the estimation of the target weight in the end-stage renal disease (ESRD) patients. The bioimpedance technique (BIS) has been postulated as a simple and non-invasive method to estimate body composition (1, 2). However, the "whole body" bioimpedance technique has been questioned in several studies (3, 8). One problem of the current bioimpedance technique is that fluid redistribution during changes in body position produced an artifact when the whole body bioimpedance analysis (WBIS) technique (wrist to ankle measurements) was used to estimate extracellular water space (ECV). Zhu et el. showed that extracellular volume was not affected by orthostatic effect when volume was estimated by the sum of segmental bioimpedance (7). The same authors introduced a technique measuring bioimpedance in three body segments, that is the arm, the leg, and the trunk and called this technique the sum of segmental BIS (WBIS) (8).

The aim of this study was to investigate the extracelullar volumes changes during hemodialysis session using the whole body bioimpedance technique (BIS) in comparison to segmental measurement from the leg and the arm.

MATERIAL AND METHODS

Patients. Eight patients were studied during 20 dialysis sessions. Sfandard bicarbonate dialysis was delivered by dialysis machines with volumetric control. All treatments were performed using polysulfone capillary dialyzers (F4, F5, F6, F7, and F8, Fresenius

Medical Care, Germany) with surface area of 1.2 to 1.8 m^2. All patients had given informed consent to participate in the study.

Bioimpedance. Whole body bioimpedance was measured for a spectrum of frequencies ranging from 5 to 500 kHz (Hydra 4200 Analyzer, supplied by Xitron Technologies Inc., San Diego, CA). Electrodes were placed on the wrist and on the ankle on the contra-lateral access side of the patient for whole body bioimpedance measurement as described elsewhere (6). In the segmental measurement, four sensing electrodes were placed on the wrist, the shoulder (acromion), the upper anterior iliac spine, and the ankle. Patients were in the supine position during the whole dialysis to eliminate the effect of position changes on bioimpedance volume estimation (8). Data were collected at the pre-dialysis time, and at the end of each dialysis session. The software supplied with the device was used to fit the impedance data to an electrical model to obtain the value of extracellular volumes. The computer was used for data storage and data analysis.

Statistical analysis. Data are presented as mean ± standard deviation (SD). Differences between groups were estimated by means of Pearson's product-moment correlations and probability (P) <0.05 was assumed to reject the null hypothesis. The statistical analysis was performed using SPSS\PC for Windows, version 9.0.

RESULTS

Treatment and bioimpedance data characteristics of twenty dialysis sessions are summarized in Table 1. Relative changes in extracellular volume as measured by segmental

Table 1. Treatment and bioimpedance data characteristics
The mean value ± SD *$p<0.05$ in comparison to Δ ECV $_{WBIS}$

	Unit	
Treatment time	hr	4.1 ± 0.2
UFV	L	2.79 ± 0.77*
Weight pre	kg	72.41 ± 8.23
Weight post	kg	69.55 ± 8.22
Δ Weight	kg	2.86 ± 0.77*
ECV $_{WBIS\ pre}$	L	17.70 ± 1.97
ECV $_{WBIS\ post}$	L	14.66 ± 1.50
Δ ECV $_{WBIS}$	L	3.042 ± 0.588
ECV $_{SBISarm\ pre}$	L	0.10 ± 0.02
ECV $_{SBISarm\ post}$	L	0.077 ± 0.02

Δ ECV $_{SBISarm}$	L	0.0224 ± 0.019
ECV $_{SBISleg\ pre}$	L	0.144 ± 0.03
ECV $_{SBISleg\ post}$	L	0.11 ± 0.018
Δ ECV $_{SBISleg}$	L	0.0329 ± 0.0178*

measurement of the leg (Δ ECV $_{SBISleg}$) significantly correlated with Δ ECV $_{WBIS}$ (p=0.04, Pearson correlation) (Fig. 1). We did not observe any correlation between Δ ECV $_{WBIS}$ and Δ ECV $_{SBISarm}$.

Relative change in ECV as measured by the whole bioimpedance technique closely following changes in total ultrafiltration removal.

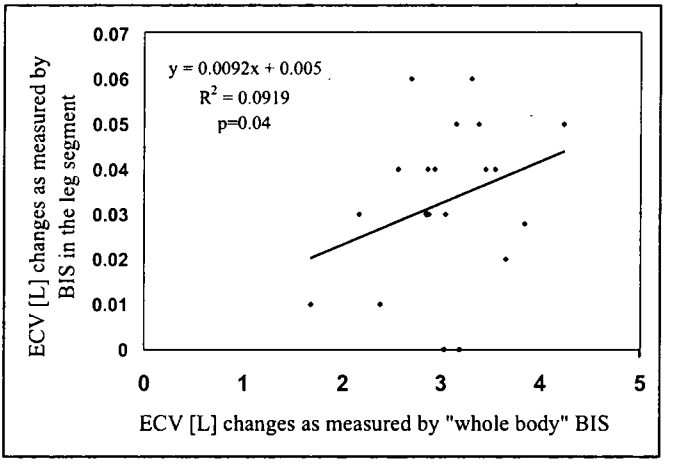

Fig. 1. Δ ECV [L] as measured by "whole bioimpedance" (Δ ECV $_{WBIS}$) technique versus Δ ECV [L] as measured by segmental bioimpedance measurement (Δ ECV$_{SBISleg}$) in the leg

DISCUSSION

Bioimpedance technique is a non-invasive method to analyze body composition and hydration (3, 5). The whole body bioimpedance measurement has been questioned in several studies (6, 7). In the whole body bioimpedance analysis extracellular volume is calculated from measurements obtained between the wrist and the ankle under the assumption that the extracellular volume can be modelled by a homogeneous, equivalent cylinder. Zhu et. al. showed that extracellular volume was not affected by changes in body position when volume was estimated by the sum of segmental bioimpedance from trunk, legs, and arms. In the previous study we postulated using the continuous ECV measurement in correlation with ultrafiltration changes for early detection of hypotension

episodes during hemodialysis sessions, but we know at present that low trunk extracellular volume is not adequately measured by the whole body bioimpedance technique, so overall change in extracellular volume was underestimated (6). In this study we compare the whole bioimpedance measurement with segmental measurement from arm, and leg. The correlation between Δ ECV $_{WBIS}$ and Δ ECV $_{SBISleg}$ has been noted as statisticaly significant.

We postulate that the segmental bioimpedance technique as measured from one simple segment such as leg may be useful in detection of fluid removal during hemodialysis procedure.

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REFERENCES

1. Deurenberg P. et al.: Multi-frequency impedance for the prediction of extracellular water and total body water. Br. J. Nutr., 73, 349, 1995.
2. Kushner R. F. et al.: Use of bioelectrical impedance analysis measurements in the clinical management of patients undergoing dialysis. Am. J. Clin. Nutr., 64, 503S, 1996.
3. Leunissen K. M. et al.: New techniques to determine fluid status in hemodialyzed patients. Kidney Int., 41, S50, 1993.
4. Scharfetter H. et al.: Effect of postural changes on the reliability of volume estimations from bioimpedance spectroscopy data. Kidney Int., 51, 1078, 1997.
5. Załuska W. et al.: Pomiar przestrzeni wodnych za pomocą techniki bioimpedancji elektrycznej w celu oszacowania wagi oczekiwanej u pacjentów hemodializowanych Przegl. Lek., 57, 707, 2000.
6. Załuska W. T. et al.: Relative underestimation of fluid removal during hemodialysis hypotension. American Society of Artificial Internal Organs Journal, 44, 823, 1998.
7. Zhu F. et al.: Dynamic of segmental extracellular volumes during changes in body position by bioimpedance analysis. J. Appl. Physiol., 85, 497, 1998.
8. Zhu F. et al.: Sum of segmental bioimpedance analysis during ultrafiltration and hemodialysis reduces sensitivity to changes in body position. Kidney Int., 56, 692, 1999.

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SUMMARY

The bioimpedance technique is postulated as not expensive and non-invasive method for measurement of body water compartments in humans. However, the accuracy of the whole body bioimpedance technique has been questioned by several authors because of nonhomogenic nature of the human body. In the present study we used the whole body bioimpedance technique in comparison to segmental measurement from the arm and leg for assessment of extracellular water compartment. The extracellular water compartment value as measured by the whole body technique significantly correlated with extracellular water compartment value measured from segmental measurement in the leg. We postulate practical use of segmental measurement from the leg as an indicator of body hydration.

Zmiany zewnątrzkomórkowej przestrzeni wodnej, mierzonej za pomocą całkowitej oraz segmentalnej bioimpedancji elektrycznej, w czasie hemodializy u pacjentów ze schyłkową niewydolnością nerek

Technika bioimpedancji elektrycznej jest postulowana jako tani i nieinwazyjny sposób pomiaru przestrzeni wodnych organizmu ludzkiego. Dokładność pomiaru opcji bioimpedancji całego ciała jest kwestionowana przez wielu autorów z powodu homogennej budowy organizmu ludzkiego. W obecnym badaniu dokonano pomiaru zewnątrzkomórkowej przestrzeni wodnej w opcji pomiaru całkowitej bioimpedancji oraz z segmentów w postaci kończyny górnej oraz dolnej u pacjentów hemodializowanych w czasie 20 sesji hemodializ. Stwierdzono istotną korelację pomiędzy wielkością przestrzeni wodnej zewnątrzkomórkowej zbadanej pomiarem całkowitym a pomiarem segmentalnym z kończyny dolnej. Autorzy postulują możliwość wykorzystania oceny nawodnienia kończyny dolnej jako wskaźnika stanu nawodnienia całego organizmu u pacjentów leczonych hemodializami z powodu terminalnej niewydolności nerek.