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Bioimpedance-based overhydration valuation in peritoneal dialysis patients is not affected by the dialysis fluid intraperitoneal inflow

Napływ płynu dializacyjnego do jamy otrzewnej u pacjentów dializowanych otrzewnowo nie wpływa na wyniki pomiaru przewodnienia metodą bioimpedancji

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S u m m a r y

Introduction. Peritoneal dialysis fluid in peritoneal cavity affects the body weight, but is overlooked by the bio-impedance measurements, as shown after draining this fluid out.

Aim. To evaluate if dialysis fluid inflow affects over-hydration measured using bio-impedance method.

Material and methods. Body Composition Monitor (Fresenius Medical Care) was used to measure water compartments in 5 male peritoneal dialysis patients, prior to, and immediately after dialysis fluid inflow.

Results. Dialysis fluid inflow did not affect over-hydration measurements, but slightly influenced anthropometric data.

Conclusions. Bio-impedance is a useful tool to evaluate current over-hydration in peritoneal dialysis patients, but for the best accuracy of longitudinal comparisons the measurement should be done after the dialysis fluid has been drained out.

Key words: peritoneal dialysis, body composition, chronic renal failure

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

Wprowadzenie. Obecność płynu dializacyjnego w jamie otrzewnej u pacjentów dializowanych otrzewnowo zmienia ciężar ciała, ale nie wpływa na odczyty pomiarów przestrzeni wodnych dokonywanych metodą bioimpedancji przed i po opróżnieniu otrzewnej, jako że płyn ten jest traktowany jako transcelularny.

Cel. Ocenić, czy napływ płynu dializacyjnego do otrzewnej wpływa na ocenę przewodnienia metodą bioimpedancji.

Materiał i metody. Pomiary wykonano u 5 dorosłych mężczyzn dializowanych otrzewnowo przed i po wpuszczeniu płynu dializacyjnego do jamy otrzewnej. Użyto Body Composition Monitor (Fresenius Medical Care).

Wyniki. Wartości przewodnienia były takie same przed i po wpuszczeniu płynu dializacyjnego, zmieniły się natomiast nieznacznie niektóre parametry antropometryczne

Wnioski. Bioimpedancja jest użyteczna w ocenie aktualnego przewodnienia u pacjentów dializowanych otrzewnowo, ale porównywanie wyników pomiarów wykonanych w dłuższych odstępach czasu wymaga, by dokonywać ich przed wprowadzeniem płynu dializacyjnego do jamy otrzewnej.

Słowa kluczowe: dializa otrzewnowa, skład ciała, przewlekła niewydolność nerek

INTRODUCTION

Euhydration, the adequate hydration, is crucial to prognosis in dialysis patients. It seems even more important than low molecular substances clearance, for it predicts outcome (1), which the clearance does not (2). Out of the range of definite over- and dehydration, hydration level is very difficult to evaluate, for it is subjective. The evaluation of patient's hydration depends mainly on clinical judgment and experience of the physician. The blood volume indicators, the vena cava diameter and plasma NTproBNP, poorly correlate with hydration status in dialysis patients (3, 4). The evaluation of hydration is so difficult for significant amounts of water can be stored in the interstitial tissue. Mild hyperhydration in dialysis patients usually presents as hypertension, decreased haemoglobin and albumin levels, which in fact reflect the increase in blood volume.

Moreover, the comorbidities frequent in patients on dialysis – diabetes, chronic heart failure, malnutrition, and hypertension, add blur to the patients' hydration image. Thus, the dialysis staff are in constant search for improved evaluation of body water content in renal patients.

Not only the water content, but also its distribution is important to health. The total body water (TBW) is contained in three separate compartments. Most of water is kept inside the cells (intracellular water – ICW) and between them (extracellular water – ECW). Some additional water (1-3% of body weight, BW) is sequestered inside the body cavities (transcellular water – TCW). The TCW is contained in peritoneal, pleural and pericardial cavities, inside the digestive tract, and the central nervous system. Measuring the ICW, TBW and ECW has been for years a cumbersome task, for it was performed with the use of dilution techniques. These techniques require time from injection to equilibration and are of no use in dynamic situations.

Lately, the bio-impedance, and the bio-impedance vector became an accepted, and widely used method to evaluate the TBW, ICW, and ECW. The basis for measurement is to evaluate body impedance to electrical currents of low (ECW+ICW) and high frequency (ECW). ICW is calculated as the difference between the two. The TCW is not registered with this method. The method is practically non-invasive, and the relevant equipment is commercially available. Among them, the Body Composition Monitor (BCM-FMC, Fresenius Medical Care, Germany), which is a bio-impedance spectroscopy device for clinical use, was validated by reference methods (5, 6), and has been also used in PD patients (7).

Peritoneal dialysis offers a unique situation, where abrupt TCW changes can be observed and directly, and precisely measured. One can expect, that intraperitoneal water and electrolyte abrupt influx should not influence the readings of ICW and ECW, alike the efflux does not interfere with them (8). It is also of interest how the increased body weight influences the derived body composition parameters.

AIM

Based on the literature reviewed we hypothesised the quick peritoneal dialysis fluid inflow would not influence the bio-impedance-based measurements of ECW, ICW, TBW and TBW excess (over-hydration), alike the emptying of peritoneal cavity does it not. We also assumed that the increased body weight resulting from peritoneal fluid inflow could influence some other BCM-FMC readings.

OBJECTIVES

The primary endpoint of this retrospective observational study adopting bio-impedance method to evaluate ICW and ECW was to register stability of ICW and ECW despite acute changes in peritoneal fluid volume. The secondary endpoint was to register changes in body parameters resulting from the abrupt changes in the weight of tissues, which are neither ECW nor ICW.

MATERIAL AND METHODS

Patients

Body water compartments were measured in adult males, stable, slightly overydrated on clinical evaluation, receiving chronic APD for CKD 5. The data were obtained at the end of staff training in using BCM-FMC in clinical practise. At this stage we performed, as a routine, the double analysis with the objective of assessing the repeatability of measurements.

Measurements

The BCM-FMC (Fresenius Medical Care), which measures the impedance spectroscopy at 50 different frequencies between 5 kHz and 1 MHz, was used to measure PD patients' hydration, and the readings were registered in medical records. The BCM-FMC is supposed to overlook the fluid sequestered within the trunk (9, 10).

Statistics

Mean and standard deviation served to evaluate data distribution, and the double tail, paired Student t-test was applied to evaluate differences between the means. All analyses were performed using standard Excell software.

RESULTS

Data on pre- and post-inflow of dialysis fluid were retrieved from the records of all PD patients. Five patients were identified to match the inclusion criteria. The basic anthropometric and bio-impedance data are presented in table 1. This table also presents immediate changes in bio-impedance-derived parameters caused by the inflow of 2000 ml of dialysis fluid into the peritoneal cavity. Body weight, both, the measured and the ideal, increased by the amount close to the instilled volume. The quality of impedance measurements was very high and not influenced by the increase in body weight. The TBW, ICW increased slightly, but the ECW changes were on the verge of significance. However, the ECW/ICW ratio remained stable. None of the lean tissue nor the fat indexes has been significantly modified by the procedure.

TBW fraction of the body weight was well below the assumed 58% (tab. 2), least when the TBW was expressed as the fraction of ideal ("dry") body weight. The over-hydration estimated in basic conditions by the BCM-FMC (3,4 l) was double of that estimated by clinical evaluation assuming TBW constitutes 58% of BW (1,57 l).

DISCUSSION

Inflow of dialysis fluid into the peritoneal cavity resulted in only minute systematic changes in ECW

Table 1. Mean values before the PD fluid inflow and the immediate changes (preinflow-postinflow) following it.

Parameter	Value (mean ± SD)	Change (mean ± SD)	p value
Age [yers]	57.4 ± 11.84		
Height [cm]	178.2 ± 4.32		
BP systolic [mmHg]	130 ± 0		
BP diastolic [mmHg]	78.0 ± 10.95		
Instilled volume (l)	1.96 ± 0.089		
BW measured [kg]	87.68 ± 7.11	-1.8 ± 0.30	0.000*
BW ideal [kg]	84.3 ± 6.61	-1.9 ± 0.5	0.000*
Over-hydration	3.4 ± 0.54	0.1 ± 0.3	0.528
BMI real	27.57 ± 1.243	-0.6 ± 0.1	0.001*
BMI calc	27.56 ± 1.258	-0.6 ± 0.2	0.001*
V	44.3 ± 5.79	-0.7 ± 0.8	0.092
OH/ECW	14.9 ± 0.98	0.6 ± 1.3	0.391
TBW	47.30 ± 5.841	-0.6 ± 0.7	0.098
ECW	22.78 ± 2.331	-0.2 ± 0.2	0.051**
ICW	24.56 ± 3.555	-0.4 ± 0.6	0.263
ECW/ICW	0.93 ± 0.048	0.0 ± 0.00	0.847
LTI	16.28 ± 2.213	-0.2 ± 0.5	0.378
FTI	10.00 ± 0.962	-0.5 ± 0.5	0.100
LTM	51.98 ± 8.728	-0.7 ± 1.8	0.448
LTM%	58.98 ± 5.269	0.9 ± 2.1	0.405
FAT	23.34 ± 1.459	-0.9 ± 1.1	0.127
FAT%	26.82 ± 3.697	-0.6 ± 1.2	0.371
ATM	31.78 ± 1.969	-1.3 ± 1.5	0.130
BCM	29.86 ± 5.896	-0.5 ± 1.3	0.407
Q	97.75 ± 0.750	-0.1 ± 0.4	0.449

*$p < 0.05$, ** – borderline statistical difference
BP – blood pressure; BW – body weight; BMI – body mass index; V – urea distribution volume; OH – overhydration; ECW – extrcellular water; TBW – total body water; ICW – intracellular water; BMI calc – BMI; FTI – ATM/height^2; LTI – LTM/ height^2; LTM – lean tissue mass; LTM% – LTM/BW; FAT – lipid mass; FAT% – FAT/BW; ATM – Adipose tissue mass; BCM – Body cell mass; Q – data quality

evaluation. The range of these changes was of no clinical significance. It is of great importance to the everyday practice the BCM-FMC evaluated over-hydration remained stable and independent of the intra-peritoneal fluid volume. As we were interested mainly in clinical applicability of BCM-FMC the small number of participants did not impact our evaluation. We are fully aware this would not be the case should we look for precise method validation.

The level of overhydration, i.e. amount of water excess, as indicated by the BCM-FMC exceeded that of clinical judgment based on the TBW = (0,58*BWideal) + overhydration. This could result from the lower "normal" water content serving as the basis for the BCM-FMC calculations. As it is presented in table 2, the water fraction of BW in fact is 0.56. This might reflect the age-induced changes in body composition, which are normally out of the clinical rough calculations. Thus, our limited data are in agreement with the large studies indicating the weakness of clinical judgment of the peritoneal patients' hydration status (11).

In general the dialysis patients, especially those on hemodialysis, oscillate between over-hydration and euhydration. The last one is usually referred to as "dry body mass". This is in contrast to the general population,

Table 2. Body weight, water compartments and overhydration (see text for details).

Parameter [unit]; n = 5	Mean ± SD
TBW – [(BWr-OH)*0.58] [kg]	1.57 ± 2.107
(TBW/0.58)-BWr [kg]	-6.13 ± 3.103
TBW/BWideal [%]	55.98 ± 2.670
TBW/BWr [%]	53.8 ± 2.40
(TBW-OH)/(BWr-OH) [%]	51.9 ± 2.35
OH/TBW [%]	7.2 ± 0.39
OH/ECW [%]	15.0 ± 0.99
OH/ICW [%]	13.9 ± 0.73

TBW – Total Body Water; BWr – Body weight measured; BWideal – Dry body weight suggested by the BCM-FMC software; OH – overhydration suggested by the BCM-FMC; ECW – extracellular water; ICW – intracellular water where over-hydration is extremely unlikely, and the individuals oscillate between euhydration and mild dehydration.

Body water is not evenly distributed. It is generally agreed, that on average water accounts for 58-60% of the ideal body weight. However, the population data show clearly that the normal water content changes with age, gender (12) and fraction of adipose tissue (13), but the lean body mass hydration of 73%, is kept constant between genders and species (14).

Some parameters of the body composition estimated by the BCM-FMC were clearly influenced by the body weight changes induced by dialysis fluid inflow. The BMI increased significantly, and sum of FAT and LTM was close to the BW changes. Thus, the body weight should be closely monitored when the measurements are to be repeated in longer intervals. We are fully aware of the limitation imposed on the study outcome brought by the small number of observations and retrospective design, but we focused on the clinical use of the BCM-FMC in mildly over-hydrated peritoneal dialysis patients.

In summary, inflow of dialysis fluid into the peritoneal cavity has clinically irrelevant impact on bio-impedance-based over-hydration measurements. Thus, the bio-impedance offers the dialysis staff an excellent non-invasive and precise tool to evaluate the current amount of excess body water in peritoneal dialysis patients. However, for the most precise evaluation of body composition changes along time, the measurements should be always taken after the peritoneal dialysate has been drained out.

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