INTRAPERITONEAL FLUID OVERESTIMATES HYDRATION STATUS ASSESSMENT BY BIOIMPEDANCE SPECTROSCOPY

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◆ **Background:** Bioimpedance spectroscopy (BIS) is a valuable tool to assess nutrition and volume status in peritoneal dialysis (PD) patients. However, data about the influence of intraperitoneal fluid on body composition measures are conflicting, and there is no clear consensus about whether the abdomen should be drained before the procedure. We designed a comparison study to detect the influence of intra-abdominal fluid on BIS results.

◆ **Methods:** We performed 73 pairs of BIS measurements in 34 stable PD patients, first with the peritoneum filled with a 1.36% glucose dialysate solution and then after the solution was drained. Patients stayed in the supine position for 10 minutes before the BIS procedure, and the electrodes were not moved between measures. Clinical and demographic data were collected, as were analytic parameters of nutrition and volume status.

◆ **Results:** Fluid overload is overestimated when BIS is performed with a full abdomen (1.82 ± 1.73 L vs 1.64 ± 1.68 L, $p = 0.043$). We also found a spurious overestimation in extracellular water (16.40 ± 3.21 L vs 16.24 ± 3.16 L, $p < 0.001$) and in relative overhydration ($8.29\% \pm 6.96\%$ vs $7.14\% \pm 6.79\%$, $p = 0.017$). No differences in intracellular water or parameters of nutrition were found. We observed negative correlations for the extracellular water overestimation with age ($r = -0.245$, $p = 0.037$), serum B-type natriuretic peptide ($r = -0.366$, $p = 0.036$), body mass index ($r = -0.248$, $p = 0.035$), and lean tissue index ($r = -0.427$, $p = 0.001$). The difference in extracellular water correlated only with body mass index ($r = -0.259$, $p = 0.039$). We also found that, assessed at 50 KHz, whole-body impedance (-4.52 ± 8.37 , $p = 0.001$) and phase angle (-0.08 ± 0.23 degrees, $p = 0.002$) were both lower when BIS was performed in patients with a full abdomen.

◆ **Conclusions:** Fluid overload is overestimated by BIS when performed in patients with dialysate in the peritoneum. The observed differences are greater in younger, more

poorly nourished, or less overhydrated patients. If more precise results are required, we suggest that the abdomen be drained before BIS is performed.

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KEY WORDS: Bioimpedance spectroscopy; body composition.

The use of multi-frequency bioimpedance spectroscopy (BIS) is becoming progressively more widespread in peritoneal dialysis (PD) units around the world. This easy and harmless procedure provides extensive data on body composition, making it an invaluable tool to assess both the nutrition and fluid status of PD patients (1). Early diagnosis of malnutrition and protein–energy wasting is key to efficient treatment (2). A precise evaluation of fluid overload can help physicians to optimize pharmacologic treatments and dialysis schedules and to better maintain residual renal function for their patients without excessive overhydration that could lead to deleterious cardiovascular effects.

Since the early days of multi-frequency BIS, studies evaluating the effect of intraperitoneal dialysis fluid have produced conflicting data (3,4). Manufacturers do not give specific instructions on whether to perform measurements with the abdomen full or empty. For the sake of speed and patient convenience, many PD units perform the test regardless of fill status. Studies that use BIS data for the evaluation of fluid or nutrition status also reflect this disparity: some perform the BIS with a full abdomen (5,6), some after the abdomen is drained (7–9), and some do not specify the fill status, assuming that there is no difference (10).

The aim of the present study was to examine the influence of intraperitoneal fluid on the results of body composition analysis by BIS in a large sample of PD patients and the factors related to any differences.

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METHODS

PATIENTS

We performed 73 pairs of measurements in 34 prevalent PD patients attending our unit. Table 1 summarizes the basal characteristics of the patients. First, patients were weighed on a calibrated scale. Body weight with an empty abdomen was considered, because intraperitoneal fluid is generally believed to be a third space. The two BIS measurements were performed no more than 2 hours apart, first with 2 L of a 1.36% glucose solution instilled, and then after the peritoneal cavity was drained. This sequence was used in all cases because we found no apparent reason why the order of the measurements would affect the results. For both measurements, patients lay in supine position for 10 minutes to achieve stable fluid redistribution. Electrodes were not replaced or moved between the measurements.

PROCEDURE

We use a BCM Body Composition Monitor (Fresenius Medical Care, Bad Homburg, Germany) to evaluate total-body electrical impedance to an alternate current at 50 different frequencies (5 – 1000 kHz). Four electrodes are placed on the patient's wrist and ankle, within a distance of 5 cm. The data obtained were a fat tissue index and a lean tissue index (LTI), intracellular and extracellular

(ECW) water, fluid overload (FO), and relative fluid overload (FO/ECW). Overhydration was defined as $(FO \times 100 / ECW) > 15\%$, according to the definition by Wizemann and colleagues (11). Because BIS has been validated against a "gold standard" method (deuterium) for evaluating fluid status, results obtained with an empty abdomen were considered to be more physiologic, and hence, reference values.

MEASUREMENTS

We concomitantly obtained serum samples from the patients for an analysis of several parameters of nutrition (albumin, prealbumin, transferrin) and fluid overload (B-type natriuretic peptide and its N-terminal fragment).

STATISTICS

All data are expressed as mean $\pm$ standard deviation because variables were all normally distributed as indicated by Kolmogorov–Smirnov tests. Parameters were compared using the Student t-test. Pearson correlation analysis was used to investigate possible relations between continuous variables, and a chi-square test was used to compare qualitative variables. Bland–Altman plots were used to show trends in the results. Values of p less than 0.05 were considered statistically significant. Statistical analyses were performed using the SPSS software application (version 15: SPSS, Chicago, IL, USA).

RESULTS

Of the 34 study patients, 52.9% were men, and mean age in the group was 58.6 ± 17.2 years. Table 2 summarizes the mean BIS results for the 73 pairs of measurements taken with a full and empty abdomen. Figure 1 characterizes the correlations for FO with a full and empty abdomen. When BIS was performed for a patient with a full abdomen, the FO and ECW increased significantly, as did the FO/ECW ratio (Figure 2). However, we did not find any difference in intracellular water, total body water, LTI, or fat tissue index.

The differences in FO when BIS was performed in the presence of intraperitoneal fluid showed statistically significant correlations with age ($r = -0.245$, $p = 0.037$), serum B-type natriuretic peptide ($r = -0.366$, $p = 0.036$), body mass index ($r = -0.248$, $p = 0.035$), and LTI ($r = -0.427$, $p = 0.001$). No relations were observed for other analytic or BIS parameters (for example, albumin, prealbumin, and fat tissue index). The difference in ECW correlated only with body mass index ($r = -0.259$, $p = 0.039$). We also found that, at 50 KHz,

TABLE 1

Demographic and Clinical Characteristics
of the Patients

Variable	Value
Sex (% men)	52.9
Mean age (years)	58.6 ± 17.2
Dialysis vintage (months)	25.3 ± 23.6
Weight (kg)	68.23 ± 12.61
Height (cm)	163.5 ± 11.45
BMI (kg/m^2)	26.03 ± 3.57
Blood pressure (mmHg)	
Systolic	142.0 ± 21.6
Diastolic	81.8 ± 12.6
Albumin (g/dL)	3.89 ± 0.33
Prealbumin (mg/dL)	35.83 ± 6.95
Transferrin (mg/dL)	182.97 ± 35.98
BNP (ng/L)	91.30 ± 89.37
Nt-proBNP (ng/L)	2190.35 ± 1561.22

BNP = B-type natriuretic peptide; NT-proBNP = N-terminal fragment of BNP.

TABLE 2
Bioimpedance Spectroscopy Results with Full and Empty Abdomen

Variable	State of abdomen		<i>p</i> Value
	Full	Empty	
Fluid overload (L)	1.82±1.73	1.64±1.68	0.043
Extracellular water (L)	16.40±3.21	16.24±3.16	<0.001
Relative fluid overload ^a (%)	8.29±6.96	7.14±6.79	0.017
Overhydration (% of patients)	85.9	84.4	NS
Intracellular water (L)	18.53±4.53	18.52±4.25	NS
Total body water (L)	34.93±7.41	34.76±7.03	NS
Lean tissue mass (kg)	37.82±10.47	37.67±9.53	NS
Lean tissue index (kg/m ²)	14.37±2.79	14.34±2.56	NS
Fat tissue mass (kg)	20.30±7.00	20.49±7.36	NS
Fat tissue index (kg/m ²)	10.78±3.82	10.86±3.87	NS
Urea distribution volume (L)	33.47±7.29	33.45±6.79	NS
Body cell mass (kg)	21.37±6.83	21.27±6.16	NS
Adipose tissue mass (kg)	27.62±9.52	27.86±10.02	NS
Phase angle at 50 KHz (°)	5.09±0.94	5.17±0.97	0.002
Total body impedance	462.14±100.66	466.66±104.44	<0.001

NS = nonsignificant.

^a Fluid overload / extracellular water.

Figure 1 — Scatterplot of fluid overload (FO) values with full and empty abdomen.

whole-body impedance (-4.52 ± 8.37 , $p = 0.001$) and phase angle (-0.08 ± 0.23 degrees, $p = 0.002$) were significantly lower.

DISCUSSION

Our study shows that intraperitoneal fluid in patients on PD can lead to overestimation of hydration status as assessed by BIS. This difference is greater in younger patients, in those with a poorer nutrition status (lower

Figure 2 — Bland–Altman analysis showing overestimation of fluid overload (FO) when abdomen is full.

body mass index, lower LTI), and in those with a smaller fluid overload (lower B-type natriuretic peptide). Hence, we suggest that, for more accurate results, the abdomen be drained before the BIS analysis.

At 50 KHz, we also observed that whole-body impedance and whole-body phase angle were lower. Impedance is an expression of the opposition of the body to the flow of the electrical current, and it is a direct reflection of the body's water content. In general terms, the greatest whole-body impedance and the largest phase angle are

achieved at a frequency of 50 KHz, when the electrical current passes through both intra- and extracellular tissues (12). The 50 KHz phase angle has been demonstrated to have prognostic value for mortality in hemodialysis and PD patients alike (8), although normalized indices may be better predictors (13). The apparent excessive overhydration observed during BIS measurement with a full abdomen produces a deviation to the left of the resistance–reactance plot as described by the Cole model (14), altering the frequency at which the maximum impedance and phase angle are achieved. That deviation is a result of a spurious decrease in the resistance of the body to the electrical current (Figure 3). To appropriately measure this parameter, BIS should also be performed with an empty abdomen.

Precise evaluation of fluid overload is important for appropriate management of the PD prescription and diuretic and antihypertensive drug dosing (15). Volume overload has deleterious cardiovascular consequences and, even if clinically undetectable, has been shown to adversely affect prognosis in PD patients (16–18). A difficult balance has to be struck to achieve the exact volume status that guarantees maintenance of residual renal function, known to be an important prognostic factor, without contributing to negative cardiovascular effects in the long term (19). The Fluid Study (20) and the IPOD-PD study are two ongoing multicentric randomized controlled trials that will add some evidence of the real efficacy of BIS for accurate volume management (1). However, evidence about whether BIS can be performed with intraperitoneal content or whether the dialysate should be drained beforehand is lacking. The manufacturer's operating instructions for the BCM device do not specify this point, and the literature so far is scarce and contradictory.

Four studies in recent years have evaluated the influence of intraperitoneal fluid content on BIS results. Than *et al.* (21) found an overestimation of total body water and ECW, and a reduction in whole-body impedance when BIS was performed with a full abdomen; however, whole-body phase angle remained unaltered. Sipahi *et al.* (22) corroborated those results, finding a correlation with echocardiographic results. More recently, Davenport (23) found the same differences in a larger sample, and he also described variations in body composition parameters. On the other hand, Parmentier *et al.* (24) could not find any significant differences.

In our study, parameters of nutrition remained unaffected by abdominal content. Only Davenport (23), using a segmental BIS device, reported an overestimation of fat and lean body content. None of the studies using the BCM device showed any difference in those measures.

Figure 3 — Reduction of impedance (length of arrow, X / R) and phase angle at 50 KHz, when bioimpedance spectroscopy is performed with an empty abdomen (solid lines) or with a full abdomen (dashed lines).

Our results confirm the findings of others suggesting that a dialysate-containing peritoneum during the BIS procedure overestimates fluid overload. It appears that some groups of patients are especially sensitive to this variation, including younger and poorly nourished patients and patients with little fluid overload. Hence, physicians should take this deviation into account if BIS is performed with a full abdomen, or for more precise results, the measurements should be taken after the dialysis solution has been drained.

DISCLOSURES

The authors have no financial conflicts of interest to declare.

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