





## LETTER TO THE EDITOR

## Discrepancies between bioimpedance spectroscopy devices in haemodialysis patients

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Optimal fluid management is a challenge in patients with end-stage kidney disease (ESKD). Most physicians still rely on physical examination, and technical aides are used in a minority of patients. Yet, subclinical abnormalities cannot be detected. As a result, acute and chronic hypovolaemia or hypervolaemia will occur in patients with ESKD. Hypervolaemia is associated with hypertension and patients experiencing chronic hypervolaemia are at increased risk of left ventricular hypertrophy, coronary artery disease and mortality [1, 2].

Acknowledging the limitations of clinical judgment of fluid status, several techniques aiming to objectively measure volume status have been developed, such as biomarker measurements, ultrasonography, blood volume monitoring and bioimpedance measurements [3, 4]. One of the most promising techniques for routine clinical application is bioimpedance spectroscopy (BIS). BIS is a non-invasive method to estimate body composition, including estimates of total body water (TBW), extracellular water (ECW) and intracellular water (ICW). As such, BIS is proposed as a useful adjunct to the clinical judgement of fluid status in patients treated with maintenance haemodialysis.

A number of commercially available devices employing bioimpedance technology are used in routine clinical practice. These devices are advertised to offer accurate estimates of the dry weight and body fluid monitoring, taking into account the patient's body composition [5, 6]. Cross-validation studies between these BIS devices are scarce and results between studies might differentiate as various devices are used.

We performed a prospective cohort study comparing two commercially available BIS devices, the Bodystat Multiscan 5000 (BSM; EuroMedix, Belgium) and the body composition monitor (BCM; Fresenius Medical Care GmbH, Germany). We measured the fluid status of 50 maintenance haemodialysis patients with a dialysis vintage of >3 months. All eligible patients were dialysed at the University Hospital Leuven and provided written informed consent.

Measurements with the two BIS devices (BSM and BCM) were performed <1 min apart, before their midweek haemodialysis session. Body water compartment parameters (ECW, ICW, TBW and hypervolaemia) as provided by the devices were analysed. Raw impedance data were collected at selected frequencies (5, 200, 500 and 1000 kHz).

The primary endpoint of this study was measured hypervolaemia, reported as overhydration by both devices. Measured hypervolaemia values were mean ( $\pm$ SD) 3.5 ( $\pm$ 1.33) L and 1.42 ( $\pm$ 1.17) L, by BSM and BCM, respectively. Agreement of patient-level data was analysed using Deming regression to take into account measurement bias. Values differed substantially when measured with BSM or BCM (Figure 1A). The BSM had a constant difference of 1.59 L (proportional bias,  $P = 0.07$ ; constant bias,  $P < 0.001$ ) as compared with the BCM.

We also analysed reported hypervolaemia exceeding an absolute threshold. We set the threshold at 3 L, as ultrafiltration volumes exceeding this threshold are considered to be high. Hypervolaemia exceeding 3 L was detected in 64% of patients according to BSM and 10% by BCM.

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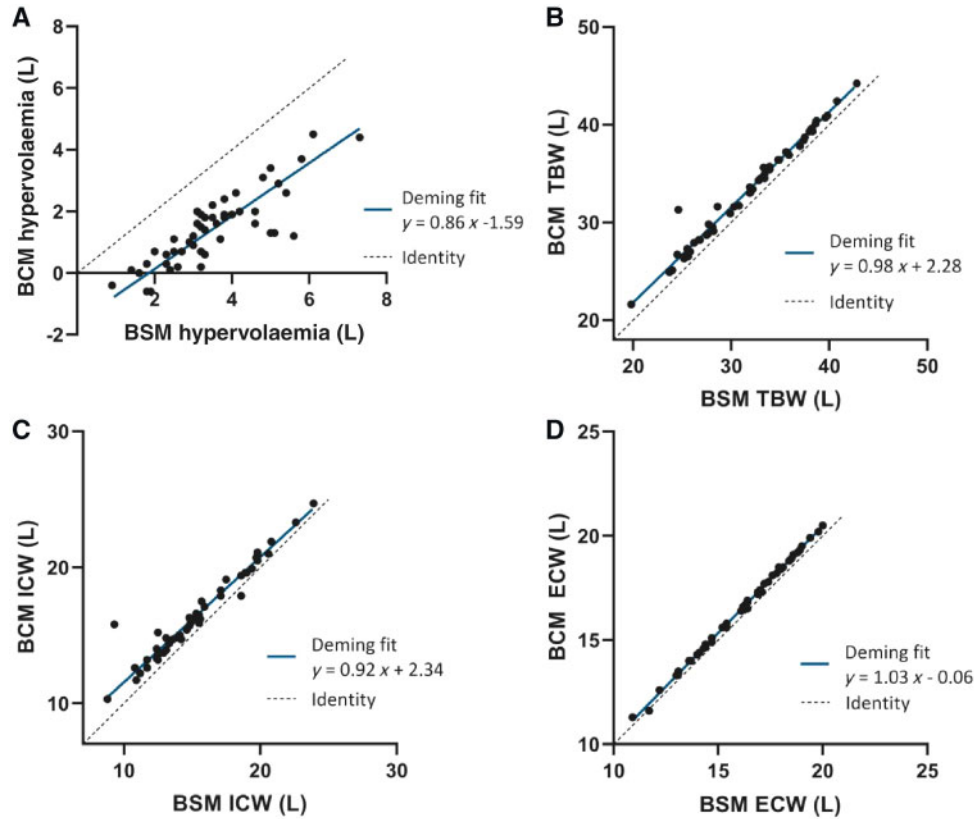


FIGURE 1: Deming regression plots of BSM versus BCM: (A) measuring hypervolaemia, (B) TBW, (C) ICW and (D) ECW of haemodialysis patients assessed by whole-body BIS.

Table 1. Descriptive statistics of the impedance data

Frequency (kHz)	BSM (mean ± SD)	BCM (mean ± SD)	Unpaired t-test (P-value)	Inter devices	
				R	P
5	577.1 ± 71.08	573.4 ± 69.54	0.7959	0.9988	<0.001
200	492.1 ± 70.62	487.7 ± 69.32	0.7506	0.9997	<0.001
500	474.1 ± 69.22	470.1 ± 68.09	0.7723	0.9997	<0.001
1000	467.8 ± 68.73	461.5 ± 67.03	0.6449	0.9996	<0.001

Mean ± SD of both devices at the four compared frequencies. Inter devices parametric tests to compare the values. Bold values were indicating a significant difference i.e.  $P > 0.05$ .

The observed clinically meaningful discrepancy in estimated hypervolaemia cannot be attributed to measurement error, as impedance data of the haemodialysis patients at the four frequencies showed acceptable agreement between the measurements of the two BIS devices (Tables 1 and 2). Despite the agreement of impedance measurements, clear discrepancies in TBW, ICW and ECW were noted (Figure 1).

Surprisingly, although estimates of water content of the different body compartments (TBW, ICW and ECW) using BCM exceed those using the BSM, estimates of hypervolaemia show quite the opposite, which cannot be explained by TBW, ECW and ICW. The estimated hypervolaemia using BSM exceeded that using the BCM.

These findings suggest caution when using both BIS devices interchangeably. Further studies are needed

Table 2. Deming regression analysis of the impedance data

Frequency (kHz)	Deming fit	Proportional bias (P-value)	Constant bias (P-value)
5	$y = 0.9783x + 8.877$	0.07	0.1
200	$y = 0.9816x + 4.601$	<0.001	0.06
500	$y = 0.9837x + 3.73$	0.003	0.1
1000	$y = 0.9753x + 5.289$	<0.001	0.03

Deming fit lines with P-values of constant and proportional bias. Bold values were indicating a significant difference i.e.  $P > 0.05$ .

to analyse the correlations between raw impedance data and measured body fluid parameters, especially hypervolaemia.

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## CONFLICT OF INTEREST STATEMENT

None declared.

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