Reliable Estimation of Dry Weight in Hemodialysis Patients by the Bioelectrical Impedance Analysis

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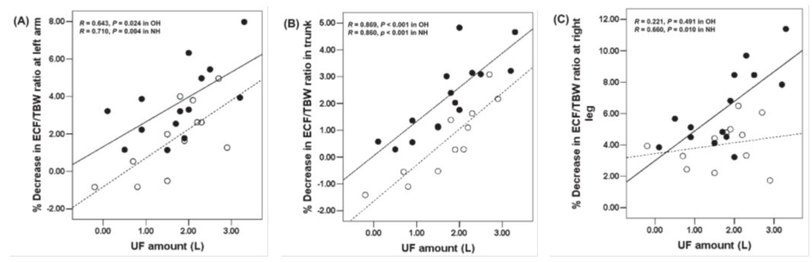
Introduction

- Management of fluid in HD patients
  - Largely dependent on a clinical assessment of dry weight (DW)
  - Require time-consuming trial-and-error process

- Bioelectrical impedance analysis (BIA)
  - 8-point tactile electrode impedance method
    - Segmental multi-frequency BIA
    - hand and foot electrodes in a standing position
    - easily performed, validated for fluid measurements
    - Drawback
      - gravity-driven fluid shift from the upper to lower extremities during BIA measurements in the standing position
      - may alter amounts of fluid in body segments

Different pattern of fluid loss from the lower extremities in normohydrated and overhydrated stage 5 chronic-kidney-disease patients after haemodialysis

SEOUNG WOO LEE, GEUN HO PARK, SEUNG WON LEE, WOOK HYUN UM, SU HYUN KWON, JOON HO SONG and MOON-JAE KIM



% change = (Pre-HD value – Post-HD value) x 100 / Pre-HD value

Nephrology 2008; 13: 109-115

Phase 1. Development of new prediction method

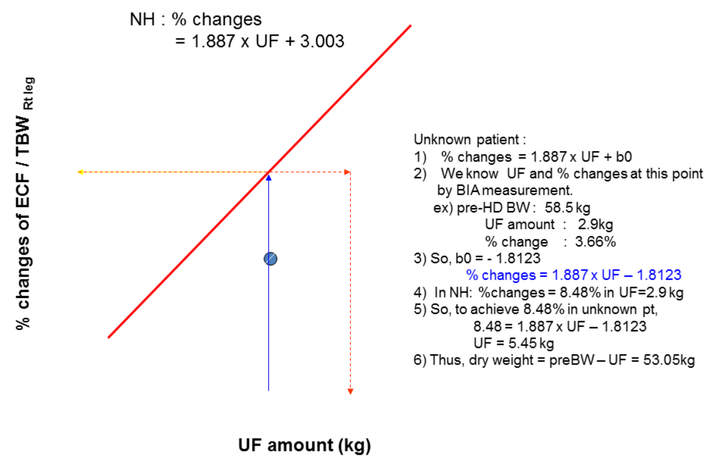
- UF amount and % changes in ECF/TBW $_{\text{Right leg}}$ ratio in NH patients

  % changes of ECF/TBW $_{\text{Right leg}}$ = UF amount (kg) x 1.887 + 3.003 ***Equation (1)***
  (R^2 = 0.504)

- Equation between UF amount and % changes of ECF/TBW $_{\text{Right leg}}$ ratio in OH patient or patient of unknown hydration status

  % changes of ECF/TBW $_{\text{Right leg}}$ = UF x 1.887 + b0 ***Equation (2)***
  (b0 = constant)

- With the data about pre-HD BW, UF amount, and % changes in ECF/TBW $_{\text{Right leg}}$ during single HD session in this patient,
  - find **b0 of equation (2)**
- **Using equation (1),**
  - **c**alculate NH patient's **% changes in ECF/TBW $_{\text{Right leg}}$ at the same amount of UF**
- Then, by applying NH patient's % changes in ECF/TBW $_{\text{Right leg}}$ to equation (2),
  - can calculate **new UF amount** to achieve NH patient's % changes in ECF/TBW $_{\text{Right leg}}$
  - Thus, using new UF amount, we can estimate DW of this patient.



Phase 2. Validation

- Measurement of ECF/TBW $_{\text{Right leg}}$ ratios by 8-point tactile-electrode BIA (Biospace Co., Seoul, Korea) before and after HD in newly enrolled NH patients
- Using current DW (cDW) of subjects as reference,
  - compared the accuracies of pDW1 (DW predicted using our devised method) and pDW2 (predicted using the normovolemia/hypervolemia slope method on the plot between ECF and BW).

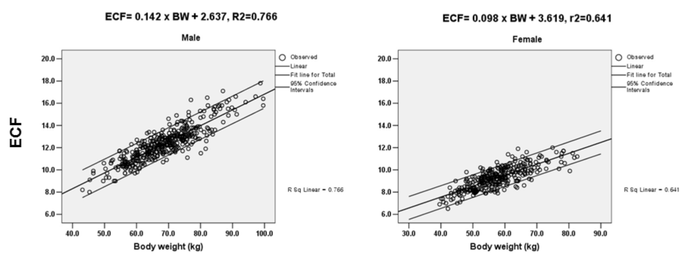
Subjects

- Inclusion criteria
  - DWs - maintained over a period of > 3 mo
  - NH on assessment of hydration status
- Exclusion criteria
  - OH or underhyrated (UH) patients on assessment of hydration status, current acute illness, amputees, liver cirrhosis with ascites, deep vein thrombosis, hemiparalysis, inability to stand unaided, a duration of HD of <6 mo, and refusal to participate
- 17 patients
- HD
  - 4 hours/session, 3 times/week, polysulfone dialyser (F6HPS, Fresenius Medical Care, Bad Homburg, Germany), Fresenius Medical Care 5008 machine

Assessment of hydration status

- NH
  - Clinical assessments of attending physicians + clinical score system + BIA
- Clinical assessment
  - Absence of symptoms and signs of hyper- or hypo-volemia,
  - No dialysis hypotension (SBP < 100 mmHg and/or symptoms requiring intervention, such as, blood flow or UF reduction, leg elevation, or saline infusion),
  - No pulmonary edema and a normal cardiothoracic ratio by chest PA,
  - No recent abrupt changes in laboratory parameters (hematocrit, serum total protein, and albumin concentrations)
- A zero score by the clinical score system
- BIA measurements
  - Whole body ECF/TBW ratio (ECF/TBW$_W$) : 0.31 - 0.35

Prediction of DW (pDW2) using the normovolemia/hypervolemia slope method on the plot between ECF and BW



normal 723 healthy Korean controls used as a control group in a previous study
Men (n=406) : age 46.9±11.0 years (range, 20-83 years), BW 68.4±9.5 kg
women (n=317) : age 47.0±11.2 years (range, 20-73 years), BW 57.5±8.3 kg

Lee SW, et al. AJKD 2003

- In HD patients, it was postulated that all ingested and metabolically derived water accumulates in ECF, and that BW increases in a 1:1 relation to fluid intake between two HD sessions
  - ECF = BW + b0 (b0 = constant)
- if we know HD patient's post-HD BW and ECF
  - can find the point of intersection between HD patient's BW and normal population's BW
- Example:
  - If female HD patient's post-HD BW 55.6kg, ECF 11.7 kg
    - 11.7 = 55.6 + b0
    - b0 = 11.7 – 55.6 = -43.9
    - ECF = BW – 43.9
  - 0.098 x BW + 3.619 (healthy female equation) = BW – 43.9
  - BW (post-HD BW = **pDW2**) = 52.68 kg

Results

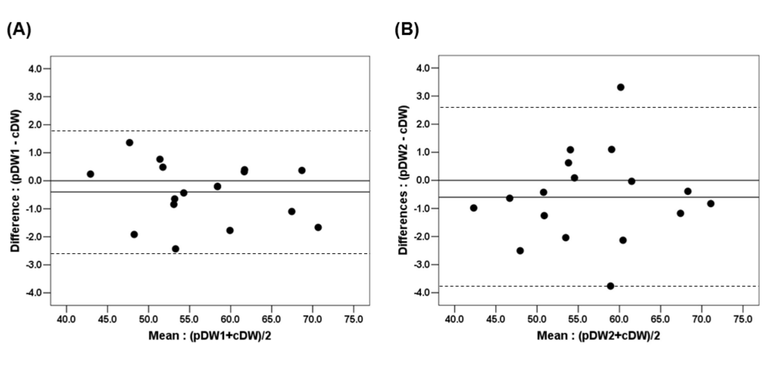
Table 1. Patient characteristics

N	17
Age (years)	49±10
Male (%)	7 (41.2%)
Height (cm)	161.1±8.5
Post-HD BW (kg)	56.9±7.9
% of DW	100.1±0.8
Duration of HD (months)	64.3±60.3
Primary renal diseases	
CGN	11
HTN	4
DMN	2
Hb (g/dL)	9.9±0.9
BUN (mg/dL)	74.8±17.6
Creatinine (mg/dL)	11.3±3.1
Serum albumin (g/dL)	4.1±0.3
Post-HD BIA data	
ECF/TBW$_W$	0.34±0.01
ECF/TBW $_{\text{Right leg}}$	0.33±0.01
No. of anti-hypertensives	1.9±1.2

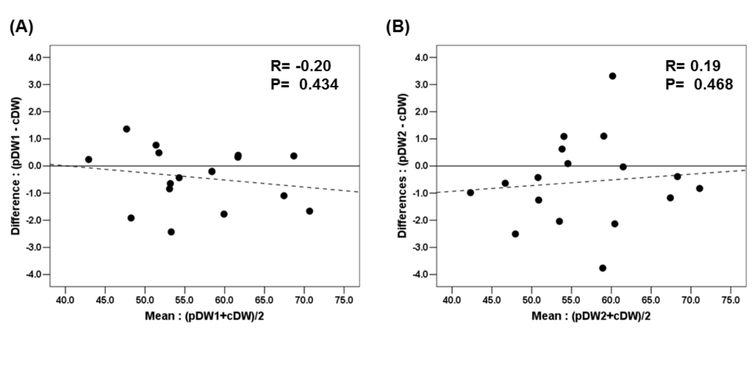
Table 2. Accuracy of the two different methods

	Mean ± S.D.	R	Differences	RMSE	Limit of agreement
cDW	56.8±7.9				
pDW1	56.4±7.7	0.985	-0.4±1.1	1.12	-2.6 ~ 1.8
pDW2	56.3±8.0	0.954	-0.6±1.6	1.69	-3.8 ~ 2.6

cDW: current dry weight,
pDW1: predicted DW using the devised method based on UF amount and % ECF/TBW ratio changes in right legs,
pDW2: predicted DW using a modification of the method developed by Chamney et al,
R: Spearman's correlation coefficients between cDW and pDW1 or pDW2,
Differences: cDW – pDW, RMSE = root mean square error



Bland-Altman plot between cDW and pDW1 (A) or pDW2 (B)
cDW: current dry weight, pDW1: predicted dry weight using the devised method, pDW2: predicted dry weight using Chamney et al's method



Correlations between differences and means (A) between pDW1 and cDW and (B) between pDW2 and cDW

Summary & Conclusion

- Based on 8-polar BIA measurements, we developed a new method of predicting DW using the relationship between UF amount and % change in ECF/TBW ratio at right lower extremities after HD.
- No significant differences were found between cDW, pDW1, and pDW2.
- The devised method appears to be as accurate as the normovolemia/hypervolemia slope method.

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Extracorporeal dialysis: techniques and adequacy - A
Moon-Jae Kim
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