

The comparative evaluation of patients' body dry weight under hemodialysis using two methods: Bioelectrical impedance analysis and conventional method

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Background: Dry weight (DW) is an important concept related to patients undergoing hemodialysis. Conventional method seems to be time consuming and operator dependent. Bio impedance analysis (BIA) is a new and simple method reported to be an accurate way for estimating DW. In this study, we aimed to compare the conventional estimation of DW with measuring DW by BIA. **Materials and Methods:** This study involved 130 uremic patients, performed in Isfahan, Iran. DW was calculated by both conventional (CDW) and BIA (BIADW) method and results were compared based on different grouping factors including sex, underlying cause of renal failure (RF) (diabetic RF and non-diabetic RF), body mass index (BMI) status, and sessions of hemodialysis. We also calculated the difference between DWs of 2 methods (DW diff = CDW-BIADW). **Results:** The mean of BIADW was significantly lower than CDW (57.20 ± 1.82 vs 59.36 ± 1.77 , P value < 0.001). After grouping cases according to the underlying cause, BMI, sex, and dialysis sessions BIADW was significantly lower than CDW. **Conclusion:** Based on the combination of problems with CDW measurement which are corrected by BIA, and more clinical reliability of CDW, we concluded that although conventional method is a time-consuming and operator-dependent way to assess DW, DW could be estimated by combining both of these methods by finding the mathematic correlation between these methods.

Key words: Bio impedance analysis, dry weight, hemodialysis

INTRODUCTION

Dry weight (DW) is a concept that was emerged simultaneously with dialysis.

Sufferers from end-stage renal disease need dialysis therapy to remove the fluid built up during interdialytic period.^[1] They undergo dialysis to maintain a "dry weight" or "target weight" which is considered as the lowest weight at which the patient can tolerate with neither hypervolemia nor hypovolemia symptoms at the end of each dialysis session.

The DW may be described as the weight at which the patient has no excessive extracellular fluid in the tissue,

the body fluid is more similar to the healthy condition, and the normal balance of fluid intake and output is maintained.

Despite major developments in the dialysis techniques, technicians still have problems in maintaining the stability of hemodynamic during hemodialysis; for this reason, patients may suffer from adverse effects of both hypervolemia (pulmonary edema and ventricular hypertrophy)^[2] and hypovolemia (hypotension and muscle cramps).^[3-7]

Therefore, precise evaluation of the hydration status and determination of DW have major roles in the treatment of patients who undergo hemodialysis.^[8]

In the clinics, post-dialysis DW is usually measured by trial and error. This conventional method is based on patient's interdialytic weight gain and clinical signs,^[3] it needs trained staff, and result is dependent on both patient's cooperation and physician's skill.^[9] However, conventional method has good clinical results, but is time consuming and operator dependent.

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Many studies tried to use new technology to achieve more reliable results that are not operator dependent. Hence, different novel methods such as bioelectrical impedance analysis (BIA) were developed.^[10]

BIA is a new and simple method in which low amplitude alternating electrical current is applied to analyze the body composition indirectly.^[11] Although this method has been evaluated in some studies, it still needs to be more investigated to be considered as a valid method.

In this study, we aimed to compare the conventional estimation of DW with measuring DW by BIA.

MATERIALS AND METHODS

This study has been registered in Isfahan University of Medical Sciences with the grant number: 391003 and it was performed in Khorshid hospital, Isfahan, Iran, between June and August of 2011.

In this study, 130 end-stage renal patients who were on the regular treatment with hemodialysis were investigated.

Patients with stable condition who were not hospitalized during the earlier 1 month entered the study. Women in the reproductive age were assessed at the mid cycle.

Patients who had pacemaker were excluded from the study.

All cases attended the hemodialysis unit. In addition to general information, ultrafiltration volume and blood pressure were recorded. The blood pressure was checked after dialysis. Finally, patients' DWs were measured by both conventional and BIA method.

Based on the underlying cause of renal failure (RF), patients were grouped into the following two categories: RF secondary to diabetes mellitus (DM) and RF secondary to non-DM causes.

Bioelectrical impedance analysis method

DW in all patients was measured by a bioelectric impedance analyses device (Maltron® Bioscan MSR 916).

The device has four electrodes. Two electrodes were attached to the upper extremity which did not have arteriovenous fistula (wrist, dorsum of 3rd metacarpi), and two electrodes are attached to the ankle and dorsum of third metatarsi. Basic information including height, weight, age, and sex are imported, and then the Bioscan calculates the DW. DW measurement was performed when dialysis was completed.

Conventional method

At the same day, after dialysis session, patients were clinically assessed by the physician regarding having edema and effusion (crackles on chest examination, ankle edema, ascites, jugular venous pressure, and blood pressure were checked). The weight at which patient had no abnormal findings suggestive of volume overload and further dialysis may lead to hemodynamic disturbance was considered as CDW.

Statistics

Data analysis was carried out with the Statistical Package for Social Sciences for Windows version 15.0.

Continues variables were presented as mean \pm standard error (SE). Paired Student's *t*-test was used to analyze continues variables as needed.

P values less than 0.05 were considered as the level of significance.

This study is approved by the ethics committee of our University and informed consent was obtained from all patients.

RESULTS

Table 1: Baseline characteristics of the patients regarding sexual distribution

Sex		Male	Female	Total	<i>P</i> value
Variable		N: 69 (53%)	N: 61 (47%)	N:130	
Age (year)		55.02 \pm 1.63	56.11 \pm 2.42	55.53 \pm 2.05	0.70
Weight (kg)		64.94 \pm 1.63	53.53 \pm 1.46	59.59 \pm 1.76	0.00
BMI (kg/m ²)		23.68 \pm 0.48	22.33 \pm 0.64	23.04 \pm 0.58	0.09
Duration of hemodialysis (months)		43.93 \pm 5.64	38.62 \pm 5.00	41.38 \pm 5.45	0.48
Ultrafiltration volume (milliliter)		3021.73 \pm 132.98	2881.14 \pm 115.94	2955.76 \pm 129.91	0.43
Systolic BP (mmHg)		128.04 \pm 2.02	125.00 \pm 2.72	126.61 \pm 2.20	0.31
Diastolic BP (mmHg)		70.50 \pm 0.96	69.01 \pm 1.16	69.80 \pm 1.09	0.32
Number of dialysis sessions per week	2 times per week	20 (15%)	23 (18%)	43 (33%)	0.19
	3 times per week	49 (37%)	38 (30%)	87 (67%)	
Underlying cause	Dm	29 (22%)	25 (19%)	54 (41%)	0.52
	non-DM	40 (31%)	36 (27%)	76 (59%)	

BMI = Body mass index; BP = Blood pressure, Data are presented as mean \pm SE or number (percentage)

Among 130 cases in this study, 69 were males and 61 were females. Baseline characteristics are given in the Table 1.

There was no significant difference between men and women in baseline characteristics except for the weight.

As mentioned before, patients' DWs were measured by both conventional (CDW) and BIA methods (BIADW).

The mean of BIADW was significantly lower than CDW (57.20±14.25 *vs* 59.36±13.87, *P* value < 0.001).

After splitting cases by sex, the same results were found [Table 2].

In order to evaluate the effects of underlying cause of RF on DW, patients were classified according to the underlying cause to diabetic RF and non-diabetic RF groups; both groups showed significantly lower BIADW than CDW. However, there was no significant difference between 2 groups in the DW measured by each of the mentioned methods [Table 3].

For determination and comparison of DW in patients with various Body Mass Index (BMI) status, patients were categorized into four groups of underweight (Below 18.5), normal weight (18.5 to 24.9), overweight (25.0 to 29.9), and obese (30 or higher).^[12]

In all four groups, mean of BIADW was significantly lower than CDW [Table 4].

Comparison of DWs of the two methods based on the dialysis sessions per week (two sessions and three sessions) showed that neither CDW nor BIADW were significantly different in these groups. However, in both of these groups, CDW was significantly higher than BIADW [Table 5].

Table 2: DW measured by BIA and conventional method compared regarding the sex

Sex	BIADW	CDW	<i>P</i> value
Male (N:69)	61.62±1.73	64.81±1.62	<0.001
Female (N:61)	52.20±1.50	53.18±1.48	<0.001
Total (N:130)	57.20±1.82	59.36±1.77	<0.001

N=Number of cases, BIADW=Dry weight by bio impedance analysis method, CDW=Dry weight by Conventional method, Data are presented as mean±SE

Table 3: Comparison of DW after grouping the patients according to the underlying cause of renal failure

Underlying disease	BIADW (kg)	CDW (kg)	<i>P</i> value
Diabetes mellitus (N:54)	58.98±1.87	61.49±1.82	0.00
Non-diabetes mellitus (N:76)	56.35±1.74	57.84±1.72	0.00
<i>P</i> value	0.30	0.14	

N=Number of cases, BIADW=Dry weight by bio impedance analysis method, CDW=Dry weight by Conventional method, Data are presented as mean±SE

We also calculated the difference between DWs of two methods (DW diff = CDW-BIADW).

Mean of DW diff among all cases was 1.92±0.30 kg (range: -8.07-11.92 kg).

DW diff was significantly higher in men than women (2.76±0.33 kg and 0.98±0.20 kg, respectively, *P* value: 0.00).

Based on the BMI status, DW diff was 1.45±0.16 kg in underweight patients, 2.10±0.32 kg in normal weight patients, 2.04±0.30 kg in overweight patients, and 0.72±0.21 kg in obese patients. There was no significant difference between these groups in DW diff (*P* value: 0.40).

Patients who underwent dialysis twice a week had 2.29±0.33 kg DW diff and those with 3 sessions per week had 1.74±0.29 kg DW diff which showed no significant difference (*P* value: 0.21).

The DW diff was significantly higher in DM group (2.53±0.39 kg) in comparison to non-DM group (1.47±0.19) (*P* value: 0.01).

DISCUSSION

It is very important to make an accurate estimation of DW in hemodialysis patients because of the essential role of DW in proper prescription of ultrafiltration volume. The more precise ultrafiltration volume is estimated, the less dialysis-related morbidities occur.^[13]

BIA has been used to measure total body water, fluid compartment size, and DW in several studies.^[14-18]

Nicholas A. *et al.* considered BIA a trustworthy method to assess DW in hemodialysis patients.^[1]

Table 4: Comparison of DW after grouping the patients according to the BMI status

BMI status	BIADW (kg)	CDW (kg)	<i>P</i> value
Underweight (N:17)	39.54±0.39	41.00±0.44	0.00
Normal weight (N:75)	54.20±1.17	56.70±1.08	0.00
Overweight (N:31)	68.00±0.71	70.04±0.75	0.00
Obese (N:7)	84.34±3.36	85.07±3.23	0.00

N=Number of cases, BIADW=Dry weight by bio impedance analysis method, CDW=Dry weight by Conventional method, Data are presented as mean±SE

Table 5: Comparison of DW after grouping the patients according to sessions of dialysis per week

Dialysis sessions per week	BIADW (kg)	CDW (kg)	<i>P</i> value
2 sessions/week (N:43)	56.11±1.55	58.41±1.51	0.00
3 sessions/week (N:87)	57.73±1.94	59.82±1.89	0.00
<i>P</i> value	0.54	0.58	

N=Number of cases, BIADW=Dry weight by bio impedance analysis method, CDW=Dry weight by Conventional method, Data are presented as mean±SE

In this study, we found that BIADW was significantly lower than CDW. This difference was also seen after dividing cases based on sex, underlying cause of RF, BMI status, and dialysis sessions. It means that according to all grouping factors, CDW is significantly more than BIADW.

Because CDW is the minimum DW at which patient is hemodynamically stable, targeting to lower values of BIADW may lead to hemodynamic disturbance.

Underestimation of DW may lead to inappropriate ultrafiltration prescription which may result in increased hemodialysis-related morbidities.^[6]

DW diff is an indicator which presents the difference between CDW which DW and BIADW.

Mean of DW diff in this study is nearly similar to the study of Chamney *et al.* in which this difference was reported to be about 1.58.^[19]

DW diff was significantly more in men than women. Moreover, it was also significantly higher in patients with underlying DM than patients with RF due to non-DM diseases. There was no significant difference between frequency of DM in men and women; thus, the higher level of DW diff could not be the impact of different sexual distribution.

It means that the degree of overestimation is higher in men and patients with diabetic end-stage renal disease, compared to the other cases. Therefore, they are at increased risks of inappropriate ultrafiltration order which is an important cause of morbidity.

What is the cause of this difference?

Bio impedance method analyzes three main compartments including body cell mass (BCM), body fat mass (BFM), and extracellular mass (ECM). Any changes or differences in these compartments may lead to different BIADW. DW diff is affected by both CDW and BIADW and given the mentioned effective factors on BIADW, DW diff is indirectly correlated to BCM, BFM, and ECM.^[11,20]

Although it was not significant, mean of diabetic patients' weight was higher than the other group. This higher weight could be due to metabolic changes of DM which make these patients' body composition different from non-diabetics.

It is well known that men and women have different anthropometric indices and different body composition. Hence, it is not surprising to find out different DW diff

in two genders. Women have more fat mass than men; therefore, men may have more proportion of extracellular fluid which can result in higher level of overestimation of CDW and lead to increased degree of DW diff.

However, in order to understand the exact causes of these differences, investigations are needed to assess and compare different body components (BFM, BCM, and ECM) of men and women, and of patients with different causes of RF, separately. The effects of gender and underlying cause on the CDW should also be studied.

In summary, based on the combination of problems with CDW measurement which are corrected in BIA, and more clinical reliability of CDW, we concluded that although conventional method is a time-consuming and operator-dependent way to assess DW, DW could be estimated by combining both of these methods by finding the mathematic correlation between these methods.

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