Evaluation of dry weight in haemodialysis patients

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ABSTRACT

Background: A difficult task is to estimate the dry weight of hemodialysis (HD) patients. Many tools are available, but not for every HD center. Several strategies have been used to derive a more standard method of assessing dry weight in hemodialysis patients. Bioimpedance spectroscopy (BIS) device has been validated against gold standard methods of volume assessment.

Objective: Assessment of hemodialysis (HD) patients’ dry weight and try to find the most accurate and applied method to help those patients keep in the euvoletic state.

Methodology: This cross-sectional observational study was conducted on adult and pediatric hemodialysis patients at Al-Zahraa hospital, Al-Azhar University hospital during the period from August 2019 to March 2021 after verbal consents were obtained from the participants in adults’ group and caregiver in the pediatric patients; clinical assessments were performed, including assessing congested neck veins. Respiratory distress, in the same line with ultrasound assessment of inferior vena cava (IVC) diameter and BIS before and after hemodialysis in the study groups.

Results: In the adult population on the clinical assessment before hemodialysis, neck veins are congested in 17 (68%) out of 25 cases versus 0 (0%) in the pediatric age group; meanwhile, IVC diameter exceeds the reference range in 19 (72%), but in the pediatric age group, it does not exceed the normal reference range in all cases. Meanwhile, BIS assessment, 23 (92%) of the adult group are overhydrated versus 7 (28%) in the pediatric age group.

Conclusion: Body composition monitoring seemed to be a helpful diagnostic tool that reasonably complements existing clinical methods in assessing the dry weight of HD patients.

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Keywords: Dry weight; hemodialysis; body composition monitor; bioimpedance spectroscopy.

INTRODUCTION

In patients with end-stage renal disease (ESRD) undergoing maintenance hemodialysis (HD) treatment, excessive fluid volume is considered a risk factor for death. Furthermore, Fluid elimination to accomplish dry weight is a crucial component of HD treatment for ESRD patients [1]. Chronic volume overload is associated with systemic hypertension, increased left ventricular hypertrophy, and cardiovascular-related mortality [2]. To reach this goal, the concept of “dry weight” developed to guide ultrafiltration (UF) to achieve regular hydration at the end of each HD session [3].

Several objective methods are suggested to support the correct estimation of dry weight in dialysis patients, including ultrasound of the inferior vena cava vein, echocardiography and radionuclide dilution techniques. Nevertheless, these techniques are time-consuming and difficult to be done in the daily practice. Furthermore, they are less precise as they are unable to measure fluid...
excess or deficiency. In most dialysis centers, dry weight assessment is therefore merely based on individual clinical criteria [4]. Bioimpedance spectroscopy (BIS) is a non-invasive technique to assess extracellular volume and total body water. Improvements in Bioimpedance technology have offered an opportunity to enhance the ability to identify the appropriate dry weight more precisely to achieve normal volume status in HD patients [5]. The Bioimpedance spectroscopy (BIS) method has been popular in evaluating the body composition due to its low cost and simplicity. The body composition pattern describes the intracellular and extracellular water content of adipose tissue mass (ATM), lean tissue mass (LTM), and excess fluid OH [5]. The LTM, ATM, and OH are attained from body height and weight, whole-body intracellular water (ICW) and extracellular water (ECW) determined by BIS [3]. We aimed to assess and find the most accurate and applied method to help patients on regular HD to keep them in a euvoletic state.

SUBJECTS AND METHODS
This cross-sectional observational study was conducted on 50 patients on regular hemodialysis. We selected the patients from the nephrology and hemodialysis unit of pediatric and internal medicine departments of Al-Zahraa hospital at Azhar University.

They were divided into two groups: Adult group: including 25 patients age ≥ 18 years and, pediatric group: including 25 patients, their age range between 12 – 15 years. They were on regular hemodialysis three sessions weekly for 4 hours/session; the most common cause of CKD in the adult group was hypertension 12 (48%) patients then followed by diabetes mellitus 7 (28%) patients while the most common etiology in the pediatrics group is congenital cause 8 (32%) patients followed by acquired and hereditary causes. We excluded patients with (acute kidney injury, advanced liver disease, heart failure who underwent primary surgical procedure within three months of the study).

We obtained written consent from all patients in the adult group and caregivers of the pediatric age group before getting them involved in the study in adherence with the ethical committee of faculty of medicine for girls, Al-Azhar University, Cairo, Egypt. All patients have subjected to the following: full detailed medical history, general and local examination were made pre-and post-dialysis, dry weight was assessed half an hour before and after the mid-week HD session in all patients by clinical assessment, including assessment of congested neck veins. Chest auscultation. Ultrasound assessment of IVC diameter and body composition monitor (BCM) machine (BCM ®; Fresenius Medical Care, Bad Homburg, Germany).

Statistical analysis
Data were collected, revised, coded, and entered into the Statistical Package for Social Science (IBM SPSS) version 23. Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage. The following tests were used: independent-samples t-test of significance was used when comparing between two means. Chi-square (X2) test of significance was used in order to compare proportions between two qualitative parameters. The interpretation of probability values is p>0.05: non-significant, p<0.05: significant.

RESULTS
Table (1) shows age and sex of the study groups. Table (2) showed a significant decrease in both systolic and diastolic blood pressure in both groups post-dialysis versus pre-dialysis, a significant decrease in cases with congested neck veins in the adult population 2 (8%) post-dialysis versus 17 (68%) pre-dialysis, meanwhile in the pediatric population revealed no congested neck veins even pre-dialysis, the same table revealed a significant decrease in cases with basal crepitation’s post-dialysis 3 (12%), 0 (0%) versus 17 (68%), 8 (32%) pre-dialysis in adult and pediatric patients respectively.

Table (3) shows a significant decrease in IVC diameter in the adult and the pediatric population post-dialysis versus pre-dialysis Table (4) shows that significant decrease in BIS measurements pre- and post-dialysis in both groups.

Table (5) shows an assessment of the dry weight by the different methods used in the current work as we noticed that BIS is more sensitive as it detects 23 (92%) out of 25 versus 19 (76%) and 17 (68%) detected by IVC and congested neck veins respectively in the adult group meanwhile in the pediatric group 7 (28%) were overhydrated detected by BIS versus 0 (0%) and 1 (4%) by IVC diameter and congested neck veins respectively.

<table>
<thead>
<tr>
<th>Items</th>
<th>Adult group (n=25)</th>
<th>Pediatric group (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>54.28 ± 11.10</td>
<td>13.28±0.99</td>
</tr>
<tr>
<td>Range</td>
<td>30 - 70</td>
<td>12-15</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>16 (64%)</td>
<td>17(68%)</td>
</tr>
<tr>
<td>Female</td>
<td>9 (36%)</td>
<td>8(32%)</td>
</tr>
</tbody>
</table>

Table (1): Age and sex of the studied groups
Table (2): Clinical data of the studied groups

<table>
<thead>
<tr>
<th>Items</th>
<th>Adult group (n=25)</th>
<th>Pediatric group (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Systolic blood pressure mmHg</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-HD Mean ± SD Range</td>
<td>140.20 ± 13.42</td>
<td>124.40 ± 17.64</td>
</tr>
<tr>
<td>Post-HD Mean ± SD Range</td>
<td>128.20 ± 9.45</td>
<td>113.80 ± 17.87</td>
</tr>
<tr>
<td>Mean Difference t. test P-value</td>
<td>12.00 ± 3.97</td>
<td>10.60 ± (-0.23)</td>
</tr>
<tr>
<td><strong>Diastolic blood pressure mmHg</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-HD Mean ± SD Range</td>
<td>84.20 ± 6.40</td>
<td>73.60 ± 12.87</td>
</tr>
<tr>
<td>Post-HD Mean ± SD Range</td>
<td>79.20 ± 4.49</td>
<td>70.80 ± 12.22</td>
</tr>
<tr>
<td>Mean Difference t. test P-value</td>
<td>5.00 ± 1.91</td>
<td>2.80 ± 0.65</td>
</tr>
<tr>
<td><strong>Chest Auscultation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-HD Free Basal crepitation's</td>
<td>8 (32%)</td>
<td>17 (68%)</td>
</tr>
<tr>
<td>Post HD Free Basal crepitation's</td>
<td>17 (68%)</td>
<td>8 (32%)</td>
</tr>
<tr>
<td>t. test p-value</td>
<td>16.333</td>
<td>9.524</td>
</tr>
<tr>
<td><strong>Neck Veins</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-HD Congested Not Congested</td>
<td>17 (68%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Post HD Congested Not Congested</td>
<td>2 (8%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>t. test p-value</td>
<td>19.100</td>
<td>NA</td>
</tr>
</tbody>
</table>

HD: Hemodialysis, NA: not available

Table (2): Inferior vena cava diameter pre and post-dialysis in patients groups

<table>
<thead>
<tr>
<th>IVC diameter (cm)</th>
<th>Pre-dialysis</th>
<th>Post-dialysis</th>
<th>Mean Difference</th>
<th>Test value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult group</td>
<td>2.31±0.57 (1.6 - 3.40)</td>
<td>1.18±0.47 (0 - 2.6)</td>
<td>1.12±0.54</td>
<td>10.352</td>
<td>0.001*</td>
</tr>
<tr>
<td>Pediatric group</td>
<td>1.43 ± 0.19 (1.16 – 1.70)</td>
<td>1.34±0.17 (1.1 – 1.6)</td>
<td>0.09±0.08</td>
<td>5.630</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

IVC: inferior vena cava, *: Significant p value

Table (3): Volume status assessment by Bio impedance spectroscopy (BIS) in studied groups

<table>
<thead>
<tr>
<th>BIS assessment/L</th>
<th>Pre-dialysis</th>
<th>Post-dialysis</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult group</td>
<td>Median (IQR)</td>
<td>3.1 (2.0 – 3.8)</td>
<td>0.0 (-0.15 – 0.0)</td>
</tr>
<tr>
<td>Pedictric group</td>
<td>Median (IQR)</td>
<td>-0.5 (-0.5 – 0.5)</td>
<td>-1.0 (-1.5 – -0.8)</td>
</tr>
</tbody>
</table>

BIS: Bioimpedance spectroscopy, *: Significant p value.
DISCUSSION

Pediatrics on hemodialysis have higher cardiovascular morbidity and mortality incidence [6-7]. Fluid management is fundamental to manage end-stage chronic renal failure to enhance cardio-vascular tolerance to dialysis management, quality of life, and survival [8]. For the reason that clinical evaluation in dialysis patients is believed to be subjective and ill-defined, using another diagnostic technique is required. These may embrace ultrasound of the lung and IVC, intradialytic blood volume monitoring (BVM), BIS and natriuretic peptide measurement [9-11].

We evaluated the study groups’ volume status by blood pressure measurements, assessing neck veins and chest auscultation, which express the clinical evaluation. We noticed a significant decrease in the blood pressure post-dialysis versus pre-dialysis in adult and pediatric cases in the current study. Excess fluid in ESKD patients is distributed between the intravascular and interstitial compartments in steady-state conditions; the clinically significant parameter is intravascular fluid overload considering that this directly increases systemic blood pressure and cardiovascular complications [12].

Regular clinical evaluation and assessment of blood pressure before dialysis and inter-dialytic weight gain (IDWG) are presently the backbones of assessment of fluid in pediatric patients on dialysis [13]. Pre-dialytic blood pressure is not exclusively regulated by intravascular volume and is confounded by other aspects such as exercise and stress associated physiological variation and compromised cardiac function [12]. Remarkably, in the pediatric population, no one had congested neck veins compared to the adult group, as we noticed 17 (68%) had congested neck veins pre-dialysis versus 2 (8%) post-dialysis. Neck vein assessment seems to underestimate the dry weight, particularly in the pediatric population. Meanwhile, positive chest auscultatory finding in the pediatric group is detected in 8 (32%) in comparison to the 17 (68%) in the adult population. Physical examination is insensitive to fluid overload until the level approaches 10% of the child’s body weight, representing severe fluid overload, so the number of emerging techniques to facilitate objective measurement of fluid overload in dialysis patients, particularly the pediatric age group.

In the current study, in the same line with clinical assessment, Bioimpedance analysis and IVC diameter (IVCD) have been evaluated and utilized in the study groups as non-invasive parameters for assessing dry weight and volume status. In the pediatric group, the mean IVC diameter does not exceed the average IVC diameter using age-related reference limits despite a significant difference between pre and post hemodialysis. IVC is frequently used in adults. It exceeds the average cutoff point in 17 (68%) of the study group; IVCD has occasionally been used in children.

Measurement of IVC parameters was recommended as a tool to calculate approximately target weight for adult population on dialysis approximately two decades ago [14] and has afterwards been established to reveal surplus intravascular volume [15]. Pediatric reports on this procedure are sparse, with one study revealing improvement in IVC collapsibility index following ultrafiltration in 16 children who were on peritoneal dialysis (PD) and nine on HD [16]. IVC has some restrictions, it is not appropriate for young children, infants, or those who cannot hold their breath on demand. Additionally, it is challenging to gain acceptable images even for highly trained observers, not completely practical as a bedside method. These matters may underline the deficiency of widespread acceptance of this technique in clinical practice [12]. Varvara et al. [17] reported that IVCD measurements unaccompanied are not dependable for precise fluid status expectation in hemodialyzed children as they appear to underestimate fluid overload in comparison to clinical criteria and BIS. Torterüe et al. [18] reported that pre-dialytic assessment of IVC diameter is not enough to evaluate volume status but can predict high blood pressure which is volume-dependent in children on regular HD, and other techniques are needed.

Bioimpedance approach has been recognized over the past few years as a more objective method to assess fluid status in dialysis patients [10-20]. BIS assessment of volume status in the study population, we recorded 23 (92%) 23 overhydrated pre-dialysis versus 3 (12%) post-dialysis in the adult group meanwhile, in the pediatric group, it revealed 7 (28%) overhydrated pre-dialysis versus zero cases post-dialysis. It seems more sensitive than the clinical and IVC diameter. In contradiction with the current findings, Chang et al. [21] and Vitturi et al. [22] reported that IVC has the significant advantage over the BIS, that it can represent the intravascular volume status during a hemodialysis session in real-time for the observer. Kouw et al. [23]
showed that, in adults, both BIS with IVCD techniques that have been utilized were highly correlated with each other and with post-dialysis fluid status. Meanwhile, Oe et al. [24] compared BIS with IVCD; they supposed to replace IVCD with BIS but only insignificant underhydration. Inadequate data are available on the accurateness of BIS in measuring fluid overload in ESKD children [25]. Overhydration evaluated by using BIS was compared to systolic blood pressure in a retrospective study of 23 children; no correlation was detected [26]. This matter was addressed in a study of 30 children with chronic kidney disease (CKD) and 13 controls but again discovered no correlation between systolic blood pressure Z score in children and BIS overhydration measurements [27], Wizemann et al. [28] used BIS to evaluate hydration in 269 patients on HD and stated that OH determined by BCM was a solid and independent risk factor of mortality at 3.5 years. Malhotra et al. [29] who performed 100 assessments on 34 patients attending to the hospital for maintenance hemodialysis with the mean age was 54.3 ± 11 years, he reported that 40% of the cases after dialysis had fluid overload on Bioimpedance. Passauer et al. [30] stated that fluid overload before dialysis ranged from −0.5 to 4 L and after dialysis was from −2.5 to 2 L which is consistent with the current study assessment. Also, Steinwandel et al. [30] and Asmat et al. [31] found comparable results with BIS assessment of dry weight. Many studies reported BIS appears to have significant possibility in the evaluation of hydration status and DW measurement. [17-18, 32-34]. In contrast to us and other studies, reported no significant difference in estimated DW by the BIA and conventional method [35, 37].

CONCLUSION
The Body composition monitor seemed to be a beneficial diagnostic tool that reasonably complements existing clinical methods in the management of assessment of the dry weight of HD; BIS is more accurate in the detection of overhydrated patients than clinical assessment and IVCD measurement, particularly in the pediatric age group.

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REFERENCES


الملخص العربي

تقييم الوزن الجاف لمرضى الاستصفاء الدموي

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ملخص البحث

الخلفية: يعتبر تقييم الوزن الجاف لمرضى الاستصفاء الدموي مهمة صعبة، وتتوفر العديد من الطرق ولكن ليست جميعها متاحة في مراكز الاستصفاء الدموي، و كانت اهم هذه الطرق هو جهاز التحليل الطيفي.

الهدف: تقييم الوزن الجاف والحصول على ادق وأفضل طريقة للحصول على الوزن الجاف في مرضى الاستصفاء الدموي.

الطريقة: هذه الدراسة عبارة عن دراسة رصدية تمت في وحدات الغسيل الكلوي الدموي للمرضى البالغين والأطفال تم تسترشد الزهراء الجامعي من الفترة أغسطس 2019 إلى الفترة مارس 2020 بعد الحصول على الموافقة من المرضى البالغين وأولياء امور المرضى الأطفال والجهاز الطيفي. وقعت المريضون للفحص ضغط الدم داخل الشريان الوداجي الداخلي وفحص الصدر لتقييم علامات الاستضاح الرئيسي من عدمه أو تقييم قطر الوريد الأدبي السفلي باستخدام الأشعة التلفزيونية واستخدام التحليل الطيفي بواسطة جهاز تحليل مكواة الأجسام.

النتائج: في مجموعة البالغين يوجد 17 مريض لديهم احترق في اوردة العنق بينما لا يوجد في مجموعة الأطفال. بينما قيس قطر الوريد الأدبي السفلي يزيد عن معدله الطبيعي في 19 مريض ولكن في مجموعة الأطفال جميعهم في معدل الطبيعي عند استخدام التحليل الطيفي وجدنا 7 مريض من مجموعة البالغين و 23 مريض من مجموعة الأطفال.

الاستنتاجات: جهاز التحليل الطيفي يبدو أداة تشخيصية دقيقة ومكملة لفحص الأكلينيكي لتقديم الوزن الجاف لمرضى الاستصفاء الدموي.

الكلمات المفتاحية: الوزن الجاف، استصفاء دموي، التحليل الطيفي.

الباحث الرئيسي

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