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Volume Control

Clinical praxis for assessment of dry weight in Sweden and Denmark: A mixed-methods study

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Abstract

Overhydration is an independent predictor of mortality in hemodialysis (HD) patients. More than 30% of HD patients are overhydrated, motivating the development of new methods for assessing hydration status. This study surveyed clinical praxis and local guidelines for dry weight (DW) assessment in Swedish and Danish HD units, and examined if differences in routines and utilization of bioimpedance spectroscopy (BIS) and other assistive technology affected frequency of DW adjustments and blood pressure (BP) levels. Cross-sectional information on praxis, guidelines and routines, plus treatment-related data from 99 stratified patients were collected. Qualitative data were analyzed with content analysis and interpreted in convergence with statistical analysis of quantitative data in a mixed-methods design. Local guidelines concerning DW existed in 54% of the units. A BIS device was present in 52%, but only half of those units used it regularly, and no correlations to frequency of DW adjustments or BP were found. HD nurses were authorized to adjust DW in 60% of the units; in these units, the frequency of DW adjustments was 1.6 times higher and systolic BP pre-HD 8 mmHg lower. There is a wide variation in routines for DW determination, and there are indications that authorization of HD nurses to adjust DW may improve DW assessment. BIS is sparsely used; its implementation may have been delayed by uncertainty over how to manage the device and interpret measurements. Hence, better methods and guidelines for assessing DW and using BIS need to be developed.

Key words: Hemodialysis, dry weight, bioimpedance spectroscopy, guidelines, blood pressure, mixed-methods design

INTRODUCTION

Hydration status is related to clinical outcome in long-term dialysis patients. Patients with overhydration (OH), defined as >15% expansion of extracellular water, have a significantly increased mortality risk.[1,2] OH is associated with left ventricular hypertrophy, left ventricular dilatation, arterial hypertension, and the development of congestive heart failure.[1,3] Conversely, dehydration is linked to intradialytic adverse events such as hypoperfusion and intradialytic hypotension (IDH).[4] Of all prevalent hemodialysis (HD) patients, 25–39% are overhydrated,[4–7] but up to 20% could be underhydrated.[6] Volume control may be insufficient, and there is a need to develop objective and reliable methods for assessing dry weight (DW).[8,9]

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To estimate OH volume predialysis, most HD patients have a determined DW, defined as the lowest tolerated postdialysis weight, achieved via gradual change, at which there are minimal signs or symptoms of hypo- or hypervolemia.[10] In everyday practice, DW is most commonly assessed using clinical methods based on case history and physical examination.[11,12] When probing for DW, blood pressure (BP) is often used as the assay variable; it is assumed that BP and extracellular volume have a direct association in HD patients.[9] However, patients can be hypertensive without signs of OH, or normotensive (BP <140 mmHg) despite OH.[2,3] Moreover, IDH should not be confused with obtaining or being below DW in all patients; in some patients, IDH is rather a consequence of excessive UF rates.[9,13]

Bioimpedance spectroscopy (BIS) is a noninvasive method to measure extracellular volume and total body water. A BIS device that has been validated in the HD population is the body composition monitor (BCM®; Fresenius Medical Care, Bad Homburg, Germany). The BCM determines whole body impedance at 50 frequencies (5–1000 kHz).[7] It analyzes the resistance and reactance of human tissue, and can measure not only fluid overload but also normally hydrated lean tissue mass and normally hydrated adipose mass.[14]

BIS has been used to guide DW assessment in randomized controlled trials, showing regression of left ventricular mass index, decrease in BP, improved arterial stiffness, and improved survival.[15,16] Thus, it is a promising method for guiding DW assessment,[4,6,7,17] but as with any technical tool there is a need for caution when interpreting and applying the results.[18,19] It has, for example, been observed that normalization of fluid status might lead to an undesirable decrease in residual urine volume.[15] Recent reviews suggest using multiple complimentary methods for assessing volume status, such as data regarding fluid balance (body weight changes), BP, biomarkers such as brain natriuretic peptides (BNP), BIS, and blood volume measurement (BVM).[9,17]

There are indications that increased frequency of DW assessment is associated with improved DW achievement and lower mortality in HD patients,[20] and it has been suggested that HD nurses (HDNs) could use BIS to help monitor OH and approximate DW in between nephrologists reviews.[21]

Because of the apparent difficulties in assessing DW, this study aimed to investigate clinical praxis and local guidelines for DW assessment in Swedish and Danish HD units, and to examine if differences in routines and utilization of BIS and other assistive technology had effects on frequency of DW adjustments and BP levels.

MATERIALS AND METHODS

Ethical approval was obtained from the Regional Ethical Review Board in Uppsala, Sweden (Reg. No. 2014/089) and the Danish Data Protection Agency (Reg. No. 2014-41-3063). All participants signed a written informed consent.

A mixed-methods design[22] was used to provide a more complete understanding of the research problem. Qualitative (open-ended) data embedded within cross-sectional quantitative (closed-ended) data were collected in parallel, analyzed separately with relevant methods of analysis, and finally integrated in a convergent interpretation.

In Spring 2014, an online questionnaire was sent to first-line managers at 68 Swedish and 24 Danish dialysis units (response rate 52%, n = 48). The responding units represented 21 of 26 counties/regions, treating 67% (n = 2826) of the total HD population of the two nations. Response rate was higher among units in university clinics than in county clinics (Figure 1). The questionnaire contained five questions concerning (1) written routines for DW assessment; (2) availability of BIS device; (3) utilization of BIS to assess DW; (4) utilization of other assistive technology to assess DW; and (5) authorization of HDNs to adjust DW. If HDNs were authorized to adjust DW, two additional questions were asked concerning (6) ways that HDNs were authorized to adjust DW and (7) whether this authorization was regulated via written guidelines.

Thirty-three units also agreed to contribute treatment-related data from three randomly chosen patients each, giving a total of 99 patients. In order to obtain good representation of the prevalent HD population,[23,24] the units were instructed to stratify the selection into two men and one woman each. The patients had to be 18 years or older, and should have started HD treatment in 2012, 2010, and prior to 2008, respectively. Staff at the units used a web-based study-specific protocol to record anonymized data on BP, UF, and DW from three predefined occasions in 2013; number of DW adjustments in 2013; and demographic data such as age, sex, and presence of diabetes, dialysis dose, and dialysis vintage.

Analysis

Statistical analysis was performed using version 21.0 of IBM SPSS Statistics for Macintosh (IBM Corp., Armonk, NY, USA). BP and UF were measured as the mean value of three predefined occasions during 2013. Values are reported as mean and standard deviation or median (interquartile range: 25th, 75th percentile). Spearman's rank correlation was used for correlation analysis of nonparametric variables (frequency of DW adjustments and BP),

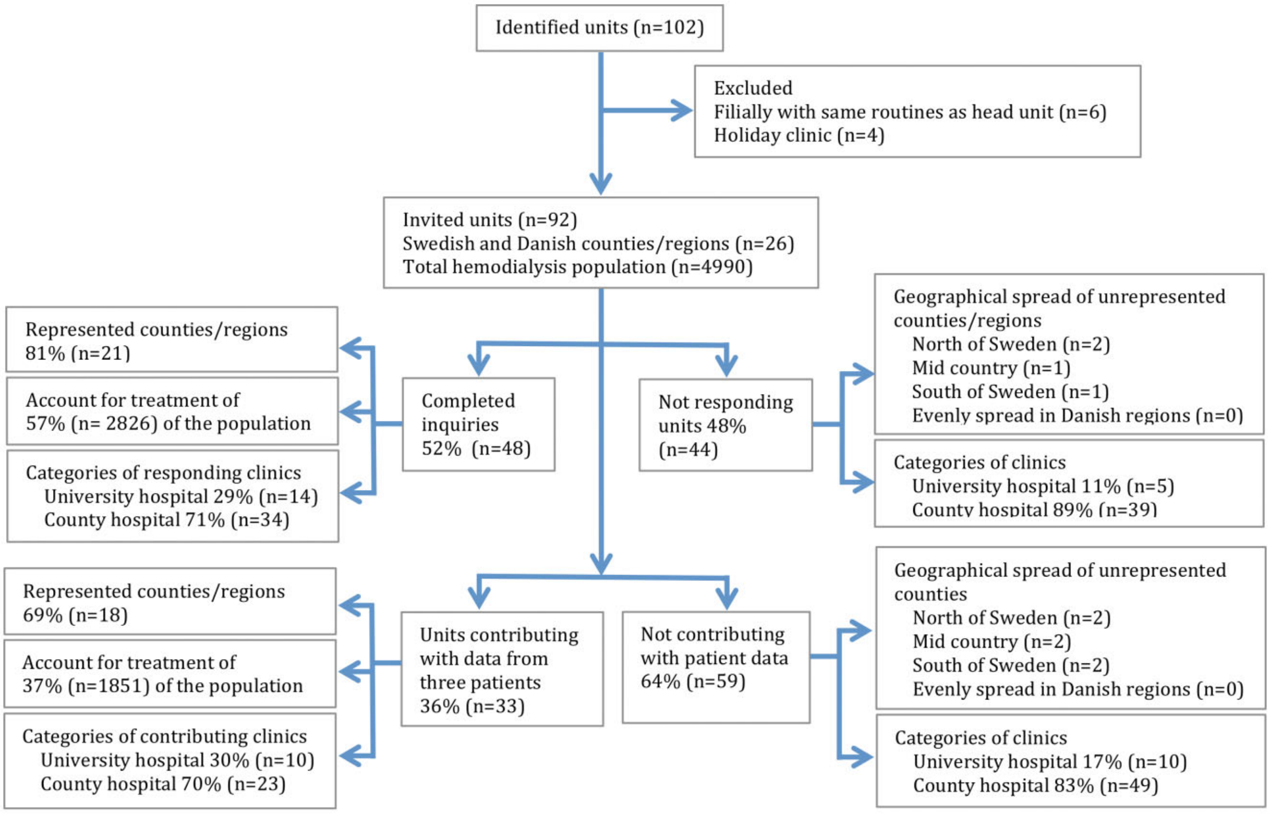

Figure 1 Characteristics of study sample.

and the phi coefficient was used to examine relationship strength in dichotomous variables (authorization of HDNs to adjust DW, presence of local guidelines, and use of BIS). An independent samples t test was used to investigate the differences in whether BIS was used and whether HDNs were authorized to adjust DW. Analyses were verified with the Mann-Whitney U test for nonparametric analysis. Level of significance was set to $P < 0.05$, and 95% confidence intervals (CIs) were calculated.

Qualitative content analysis[25] was performed to analyze written local guidelines and answers to open-ended questions from the questionnaire. Guidelines and answers were read through several times, while keeping the aim of the study in mind, to obtain a sense of the whole. Meaning units (paragraphs containing aspects related to each other through their content and context)[26] were then extracted and brought together into one document. The meaning units were sorted into two content areas, dealing with two specific topics: (1) routines of DW assessment and (2) utilization of BIS. Next, each meaning unit was condensed into a description close to the manifest content of the text, and labeled with a code. Finally, codes from the two content areas were compared for differences and similarities, and sorted into categories.

RESULTS

Written local guidelines addressing DW assessment existed in 54% of the responding units, and a device for BIS measurement was available in 52%. A majority used chest X-ray and BVM for assessing DW, 17% used ultrasound of vena cava, and 15% used serum N-terminal pro-BNP. One unit used cardiothoracic index, and one used central venous pressure (Figure 2). In terms of differences in routines, one prominent factor was that HDNs in 29 of the 48 units (60%) were authorized to change DW (Table 1), although only 14 of those 29 units had the authorization regulated via written local guidelines. The authorization of HDNs to change DW was positively correlated with frequency of DW adjustments ($r = 0.243$; $P = 0.016$) and negatively correlated with systolic BP pre-HD ($r = -0.221$; $P = 0.031$). No other significant correlations were found (Table 2).

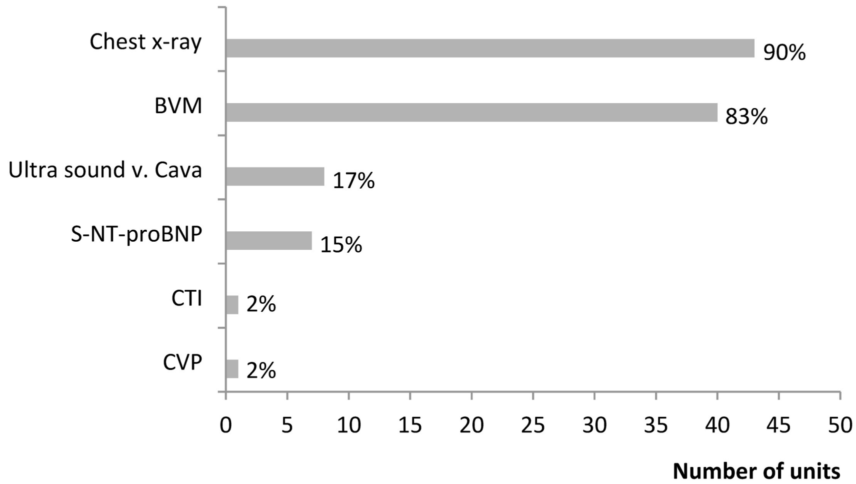

Figure 2 Utilization of technological assistance for assessing dry weight.
BVM = blood volume measurement; v. cava = vena cava; S-NT-pro-BNP = serum N-terminal pro-brain natriuretic peptide; CTI = cardiothoracic index; CVP = central venous pressure.

The availability of BIS had no effect on frequency of DW adjustments or BP, regardless of frequency of use (Figure 3). However, where HDNs were authorized to change DW, DW was adjusted 8.1 ± 6.9 times in 1 year, and systolic BP pre-HD was 138 ± 20 mmHg. In the remaining units, DW was adjusted 5.1 ± 4.5 times (t = 2.7, P = 0.009, CI: 0.79–5.38), and BP was 146 ± 12 mmHg (t = −2.6, P = 0.012, CI: −14.7 to −1.9). Diastolic BP pre-HD or BP post-HD was not affected. Descriptive statistics revealed no relevant demographical differences between units where HDNs were and were not authorized to change DW (Table 3). HDNs were more likely to be authorized to change DW in county clinics than in university clinics (66.7% vs. 44.4%, P = 0.044).

Table 1 Distribution of guidelines, BIS, and authorization of HDNs in units

	Yes		No	
Written local guidelines addressing DW assessment	54%	n = 26	46%	n = 22
BIS available at unit	52%	n = 25	48%	n = 23
HDNs authorized to change DW	60%	n = 29	40%	n = 19

BIS = bioimpedance spectroscopy; DW = dry weight; HDNs = hemodialysis nurses.

Content area 1: Routines of DW assessment

Two categories emerged in the analysis of meaning units related to *routines of DW assessment*: (1) approach to the concept of DW; (2) authorization of HDNs to adjust DW. The categories are summarized below and illustrated with excerpts from the texts. The participating units are identified with random numbers and labeled with the type of clinic: county hospital (CH) or university hospital (UH).

Table 2 Matrix of correlations

	Frequency of DW adjustments	Presence of local guidelines for DW assessment	BIS available at unit	Systolic BP pre-HD
HDNs authorized to change DW	0.243[a]	−0.038	0.190	−0.221[a]
Frequency of DW adjustments		−0.012	0.179	0.166
Presence of local guidelines for DW assessment			−0.026	−0.118
BIS available at unit				−0.045

[a]Correlation is significant at the 0.05 level (two tailed).
BIS = bioimpedance spectroscopy; BP = blood pressure; DW = dry weight; HD = hemodialysis; HDNs = hemodialysis nurses.

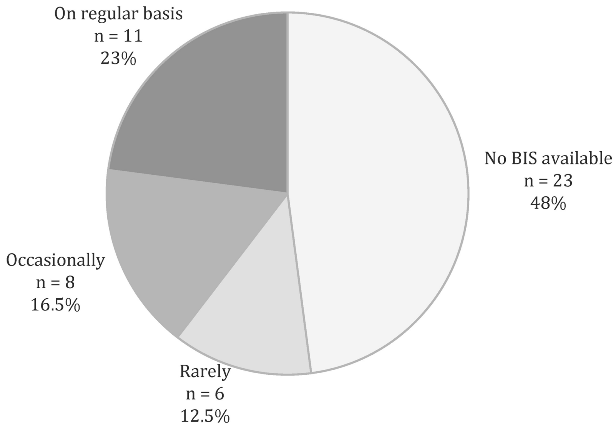

Figure 3 Bioimpedance spectroscopy (BIS) was available in 52% (n = 25) of the units. Extent of use varied across units.

Approach to the concept of DW

DW was evaluated at monthly or up to 3-month intervals. Some units had a flexible approach to DW; HDNs were able to adjust the goal for UF from treatment to treatment. One unit aimed for a positive hydration status of 1.0–1.5 L to retain residual kidney function. To prevent intra- and/or interdialytic adverse events, this unit recommended anuric patients to be 0.5–1 L OH post-dialysis.

Another approach was to restrict the UF rates to prevent adverse events.

> A round with the nephrologist responsible for care is supposed to be held every two months [. . .] the patient's quality of life, lab results, and DW are reviewed. Unit 30, CH

> Residual kidney function should be retained: aim for 0.5–1 L of OH in anuric patients, and 1–1.5 L if remaining kidney function. Unit 16, CH

Authorization of HDNs to adjust DW

The HDNs were obliged to question the plausibility of DW. However, whereas some units gave them the authority to increase or decrease DW by 0.5–1.0 kg, others considered adjustment of DW to be solely a nephrologist's responsibility, with HDNs only able to propose adjustments.

The main reason for HDNs to adjust DW was the absence of nephrologist. HDNs would adjust DW with the consent of the patient when identified as being under or overhydrated, or if the HDN found it impossible or implausible to reach current DW. HDNs would base their judgment on experience, technical aids such as BVM and BP measurement, and clinical assessment.

Some units regulated the HDNs' authorization via written local guidelines or individual delegation, whereas others advised HDNs to discuss adjustments of DW with their colleagues. In some units, the nephrologist was supposed to be alerted immediately to approve

Table 3 Descriptive data of study sample (n = 99), divided by whether or not HDNs have authority to change DW

	Patients in units where HDNs have authority to change DW (n = 60)		Patients in units where HDNs *do not* have authority to change DW (n = 39)	
Clinic (university)	20%	n = 12	38.5%	n = 15
Sex (male)	68%	n = 41	67%	n = 26
Diabetes	33%	n = 20	33%	n = 13
Hospitalized due to OH in 2013	22%	n = 13	21%	n = 8
Age (years)	70 ± 15		69 ± 11	
DW (kg)	78.2 ± 21.3		76.9 ± 17.8	
Dialysis vintage (months)	50 ± 40		60 ± 45	
Treatments per week	3.1 ± 0.4[a]		3.4 ± 0.9[a]	
Hours per treatment	4.1 ± 0.6		3.9 ± 0.5	
UF per dialysis (L)	2.3 ± 1.0		2.2 ± 0.9	
Systolic BP pre-HD (mmHg)	138 ± 20[a]		146 ± 12[a]	
Diastolic BP pre-HD (mmHg)	69 ± 12		72 ± 12	
Systolic BP post-HD (mmHg)	131 ± 22		138 ± 15	
Diastolic BP post-HD (mmHg)	68 ± 12		67 ± 10	
Adjustments of DW in 2013 (n)	8.1 ± 6.9[a]		5.1 ± 4.5[a]	

Percentage and numbers for categorical data, mean ± standard deviation for numerical variables.
[a]Difference is significant at the 0.05 level (two tailed).
BP = blood pressure; DW = dry weight; HD = hemodialysis; HDNs = hemodialysis nurses; OH = overhydration; UF = ultrafiltration.

nurse-initiated adjustment of DW, while in other units the nephrologist was supposed to be alerted before the next treatment or before any further changes of DW. In a few units, the adjusted DW was evaluated at the next round or when there was an opportunity.

> We do it [adjust DW] if the nephrologist is not around, and ask for the nephrologist's prescription retrospectively, usually in agreement with the patient, clinical examination, and BVM via the dialysis machine. Unit 13, CH

> In this unit the nurse may increase or decrease DW by 0.5 to 1 kg a few times, before the nephrologist is consulted—to confirm the new DW in the medical journal. Unit 36, UH

Content area 2: Utilization of BIS

Five categories emerged in the analysis of meaning units related to *utilization of BIS*: (1) frequency of use; (2) initiative; (3) indications; (4) barriers to utilization; and (5) implementation.

Frequency of use

Among the units with access to BIS, there were three levels of utilization: regular use, occasional use, and rare use (Figure 3). Eleven units used BIS every 2–3 months, every month, or more often; either in all patients, or in all incident patients. Eight units used BIS occasionally but had no routine for utilization. Six units used BIS rarely.

Initiative

In some units, HDNs initiated the use of BIS, whereas other units only used it on the nephrologist's demand. In a couple of units, the dietician initiated use of BIS.

> Bioimpedance may be used on the initiative of either the nephrologist or the nurses. Unit 26, UH

> In cooperation with dieticians. Unit 35, UH

Indications

BIS was mainly used when probing for DW, or if the HDN suspected DW was wrong or the patient was OH. One unit used it for patients who were impossible to weigh on a scale, and another unit used it when helping patients lose weight before transplantation. In some units, it was used in clinical trials or in peritoneal dialysis (PD) patients and in chronic kidney disease patients not on dialysis.

> To see if the patient is losing weight correctly, i.e. decreased adipose tissue and not lean tissue before or after kidney transplantation. Unit 18, CH

> When starting up dialysis, changing DW, doubtful of DW, patients impossible to weigh on a scale, and in quarterly review. Unit 9, CH

Barriers to utilization

The most common reason for not using BIS was a lack of routines. Some units only had the device on loan, and the requirement of nephrologist's approval for each patient's BIS could also have an influence. A couple of units reported their physician being dubious. In some units, the device was mainly used for PD patients.

> Right now we don't have any nephrologist who trusts BIS; it makes it difficult to use. Unit 7, CH

> The device is in a nearby building where the PD unit is located. It is primarily used in those [PD] patients. Unit 19, UH

Implementation

Most units lacking a routine for use of BIS had an ongoing discussion on what would be best practice. These units aimed for regular use on all prevalent patients or on incident patients. The need for serial measurements was mentioned.

> We aim to measure all patients three times in a row, the same day of the week for three weeks. Unit 25, CH

> We are working on a monthly routine. Unit 34, CH

DISCUSSION

There is no gold standard for DW determination,[27] and a large proportion of all prevalent HD patients being OH[4–7] suggests volume control is insufficient. This study reveals wide variation in routines for DW determination, as well as differences in approach to the concept of DW. The interval for nephrologist's evaluation of DW could vary from once a month to every third month, and the initiative to adjust DW was often taken by HDNs. Charra[11] states that DW is a crucial component of dialysis adequacy, and that achievement of DW is feasible on pure clinical grounds. Conversely, Covic and Onofriescu[18] argue for the need to reevaluate the actual concept of DW, and suggest weekly BIS measurements to replace clinical DW assessment. Mamat[21] proposes that HDNs could be trained to use a BIS device to obviate OH in HD patients between nephrologist's reviews. This approach appears to be in practice in our sample (especially in many CHs), where HDNs were authorized to adjust DW. Authorization of HDNs to adjust DW was associated with lower BP and higher frequency of DW adjustments. The effect of frequency of DW adjustments on patient outcome is scarcely investigated. However, one previous study indicates that increased frequency of DW adjustment is associated with improved DW achievement and lower mortality.[20] Thus, there is a need for further studies to investigate whether more frequently adjusted DW correlates causally to better BP control and decrease of cardiovascular complications. Adequate hydration status is fundamental to HD adequacy, but the use of BP as a parameter for improved DW has been questioned.[9] Target BP level is not as clearly defined in HD patients as in patients with normal renal function. Both high and low BP correlate with increased cardiovascular morbidity and mortality,[28] but it is still common practice to use BP as the assay variable when probing for DW.[11]

BIS has been proposed as a convenient tool for assessing DW,[4,6,7,15,17,29] and prospective trials with regular utilization of BIS—at least once a month[4,6,15]—indicate that OH and BP can be attenuated, and left ventricular hypertrophy and arterial stiffness can be improved. However, caution has been called for when implementing technical tools in a fragile population. There is a risk that continual weight loss aimed at a normovolemic hydration status, driven by BIS, will comprise residual renal function and worsen intradialytic symptoms.[15,19] Remarkably, the benefit of preserved residual renal function was highlighted in only one unit's local guidelines. Loss of residual renal function is associated with reduced survival, increased left ventricular mass index, increased BP and reduced removal of uremic toxins.[30] Obtaining the optimal DW is therefore a delicate treatment task, trying to avoid both OH and dehydration. Serial BIS measurements and trends are suggested to be more useful than single determinations, and one should bear in mind that the normal range of hydration varies from −1.1 to +1.1 L.[31] Sweden and Denmark, like many other countries,[18,19,32] still have no established guidelines for using BIS. Half of the units had a BIS device, but only half of them used it regularly, revealing a deficiency in implementation. Our qualitative analysis showed that delay of implementation might, for example, be explained by uncertainty over how to handle the device or how to interpret measurements, or dubiousness due to lack of evidence.

Reviews suggest not using BIS alone, but instead using multiple complimentary methods for assessing DW.[9,17] Some units used ultrasound of vena cava and BNP, and the vast majority used BVM. No guidelines advocate the use of chest X-ray for DW assessment; nevertheless, most units reported use of the method. Unfortunately, no data are available on the frequency of use of these methods.

One limitation of this study is that the web-based questionnaire was study specific and not validated, raising a risk for bias in responding.[33] On the other hand, a study-specific protocol enabled the use of mixed methods, which contributed to a more thorough description of clinical praxis, local guidelines, and routines for assessing DW than either quantitative or qualitative approaches could provide alone. Mixed-methods research builds on the strengths and reduces the weakness of both quantitative and qualitative approaches.[22] Moreover, electronic data collection (e.g., via the web) produces response rates higher than traditional mail methodology.[34] It may be argued that the inference, and thus the generalizability, could be limited by a response rate of 52%. However, the average response rate for studies using data collected from organizations is 35.7%.[34] Moreover, the study provides good geographic and demographic representation of Swedish and Danish HD units.[23,24]

CONCLUSION

There is wide variation in routines for DW determination in Swedish and Danish dialysis units. The authorization of HDNs to adjust DW was correlated to higher frequency of DW adjustments and lower systolic BP, suggesting improved DW assessment. However, no correlation was found between availability of BIS and frequency of DW adjustments or BP; this might be explained by the limited use of BIS. Uncertainty over how to manage the device and interpret measurements may have delayed implementation. Better methods and guidelines for DW assessment and the use of BIS need to be developed and evaluated in prospective studies.

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DISCLOSURE

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REFERENCES

1 Wizemann V, Wabel P, Chamney P, et al. The mortality risk of overhydration in haemodialysis patients. *Nephrol Dial Transplant*. 2009; **24**:1574–1579.
2 Wabel P, Moissl U, Chamney P, et al. Towards improved cardiovascular management: The necessity of combining blood pressure and fluid overload. *Nephrol Dial Transplant*. 2008; **23**:2965–2971.
3 Chazot C, Wabel P, Chamney P, Moissl U, Wieskotten S, Wizemann V. Importance of normohydration for the long-term survival of haemodialysis patients. *Nephrol Dial Transplant*. 2012; **27**:2404–2410.
4 Machek P, Jirka T, Moissl U, Chamney P, Wabel P. Guided optimization of fluid status in haemodialysis patients. *Nephrol Dial Transplant*. 2010; **25**:538–544.
5 Antlanger M, Hecking M, Haidinger M, et al. Fluid overload in hemodialysis patients: A cross-sectional study to determine its association with cardiac biomarkers and nutritional status. *BMC Nephrol*. 2013; **14**:266.
6 Moissl U, Arias-Guillén M, Wabel P, et al. Bioimpedance-guided fluid management in hemodialysis patients. *Clin J Am Soc Nephrol.* 2013; **8**:1575–1582.
7 Passauer J, Petrov H, Schleser A, Leicht J, Pucalka K. Evaluation of clinical dry weight assessment in haemodialysis patients using bioimpedance spectroscopy: A cross-sectional study. *Nephrol Dial Transplant*. 2010; **25**:545–551.
8 Kraemer M. A new model for the determination of fluid status and body composition from bioimpedance measurements. *Physiol Meas*. 2006; **27**:901–919.
9 Rosner MH, Ronco C. Techniques for the assessment of volume status in patients with end stage renal disease. *Semin Dial*. 2014; **27**:538–541.
10 Sinha AD, Agarwal R. Opinion: Can chronic volume overload be recognized and prevented in hemodialysis patients? *Semin Dial*. 2009; **22**:480–482.
11 Charra B. Fluid balance, dry weight, and blood pressure in dialysis. *Hemodial Int*. 2007; **11**:21–31.
12 Raimann J, Liu L, Tyagi S, Levin NW, Kotanko P. A fresh look at dry weight. *Hemodial Int*. 2008; **12**:395–405.
13 Flythe JE, Brunelli SM. The risks of high ultrafiltration rate in chronic hemodialysis: Implications for patient care. *Semin Dial*. 2011; **24**:259–265.
14 Chamney PW, Wabel P, Moissl UM, et al. A whole-body model to distinguish excess fluid from the hydration of major body tissues. *Am J Clin Nutr*. 2007; **85**:80–89.
15 Hur E, Usta M, Toz H, et al. Effect of fluid management guided by bioimpedance spectroscopy on cardiovascular parameters in hemodialysis patients: A randomized controlled trial. *Am J Kidney Dis*. 2013; **61**:957–965.
16 Onofriescu M, Mardare NG, Segall L, et al. Randomized trial of bioelectrical impedance analysis versus clinical criteria for guiding ultrafiltration in hemodialysis patients: Effects on blood pressure, hydration status, and arterial stiffness. *Int Urol Nephrol*. 2012; **44**:583–591.
17 Davies SJ, Davenport A. The role of bioimpedance and biomarkers in helping to aid clinical decision-making of volume assessments in dialysis patients. *Kidney Int*. 2014; **86**:489–496.
18 Covic A, Onofriescu M. Time to improve fluid management in hemodialysis: Should we abandon clinical assessment and routinely use bioimpedance? *Clin J Am Soc Nephrol.* 2013; **8**:1474–1475.
19 Daugirdas JT. Bioimpedance technology and optimal fluid management. *Am J Kidney Dis*. 2013; **61**:861–864.
20 Coogan L, Barlow J, Saran R, et al. Dialysis facility practices aimed at target weight achievement and patient outcomes in DOPPS. ASN Annual Meeting–Denver [abstract]. *J Am Soc Nephrol*. 2010; **21**:467A.
21 Mamat R, Kong NCT, Ba'in A, et al. Assessment of body fluid status in hemodialysis patients using the body composition monitor measurement technique. *J Clin Nurs*. 2012; **21**:2879–2885.
22 Creswell JW. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 4th edn. Los Angeles (CA): Sage; 2014.
23 Danish Nephrology Registry (DNR). *Annual Report 2013 [Internet]*. 2013. Available from: http://www.nephrology.dk/Publikationer/Landsregister/%C3%85rsrapport%202013.pdf (accessed date: January 13, 2015).
24 Svenskt njurregister (SNR). *Årsrapport 2014 [Internet]*. 2014. Available from: http://www.medscinet.net/snr/rapporterdocs/SNR%20%C3%85rsrapport%202014_Webb.pdf (accessed date January 13, 2015).
25 Krippendorff K. *Content Analysis: An Introduction to Its Methodology*, 3rd edn. Thousand Oaks (CA): Sage; 2013.
26 Graneheim UH, Lundman B. Qualitative content analysis in nursing research: Concepts, procedures and measures to achieve trustworthiness. *Nurse Educ Today*. 2004; **24**:105–112.
27 Kuhlmann MK, Zhu F, Seibert E, Levin NW. Bioimpedance, dry weight and blood pressure control: New methods and consequences. *Curr Opin Nephrol Hypertens*. 2005; **14**:543–549.
28 Stern A, Sachdeva S, Kapoor R, Singh J, Sachdeva S. High blood pressure in dialysis patients: Cause,

pathophysiology, influence on morbidity, mortality and management. *J Clin Diagn Res*. 2014; **8**:ME1–ME4.

29 Onofriescu M, Hogas S, Voroneanu L, et al. Bioimpedance-guided fluid management in maintenance hemodialysis: A pilot randomized controlled trial. *Am J Kidney Dis*. 2014; **64**:111–118.

30 Vilar E, Farrington K. Emerging importance of residual renal function in end-stage renal failure. *Semin Dial*. 2011; **24**:487–494.

31 Wabel P, Chamney P, Moissl U, Jirka T. Importance of whole-body bioimpedance spectroscopy for the management of fluid balance. *Blood Purif*. 2009; **27**:75–80.

32 Canadian Agency for Drugs and Technologies in Health. *Bioimpedance Devices for the Assessment of Body Fluid Volume for Patients Undergoing Dialysis: A Review of the Clinical Effectiveness, Cost-Effectiveness, and Guidelines [Internet]*. 2014. Available from: http://www.ncbi.nlm.nih.gov/books/NBK268823/ (accessed date: May 13, 2015).

33 Streiner DL, Norman GR. *Health Measurement Scales: A Practical Guide to Their Development and Use*. New York: Oxford University Press; 2008.

34 Baruch Y, Holtom BC. Survey response rate levels and trends in organizational research. *Hum Relat*. 2008; **61**:1139–1160.