Haemodialysis dry weight assessment: A literature review

Susana San Miguel

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Abstract

Background: One goal of haemodialysis is to ensure that fluid removal is optimal and with minimal or no adverse reaction from the treatment. Accurately assessing dry weight is crucial in providing effective and safe haemodialysis.

Aim: To explore the clinical relevance of dry weight assessment and to identify and discuss various methods of assessing dry weight in adult haemodialysis patients through comprehensive search of current literatures.

Methods: Electronic search of health-related databases of publications from 2005-2009 were searched

Results: The literature revealed various methods of assessing dry weight including: clinical, non-clinical and biochemical methods. Each of these methods has its own merits and limitations. Several studies have been conducted on the new technologies in assessing dry weight but there is still a lack of larger, randomized controlled trial to support the use of a particular method.

Conclusion: Although various technologies have assisted clinicians in managing effective fluid removal and dry weight assessment, the validity and clinical applications of these have been limited. This is either because of the cost involved, or the lack of randomized-controlled trial to examine its usefulness in the clinical setting.

Key Words
haemodialysis, interdialytic weight, weight, blood volume, hypotension

Introduction

Haemodialysis (HD) is a form of renal replacement therapy, which offers a means of removing retained fluid, electrolytes and waste products (Purcell, Manias, Williams, & Walker, 2004). The goal of each HD session is to ensure that fluid and solute removal is optimal and as comfortable to the patient, that is, there are minimal or no adverse reaction from the treatment such as hypotension, cramps and dizziness (Corea, Christensen, & Vogel, 2005).

For dialysis staff to ensure that fluid removal is optimal and as comfortable as possible to the patient, dry weight (DW) assessment is crucial. This is often difficult to achieve in the haemodialysis setting because of the lack of reliable criteria to determine whether DW has been reached in a particular patient (Zellweger, Querin, & Madore, 2004), or the lack of evidence to support a particular method of assessment. This is often compounded by the potential for haemodynamic instability during ultrafiltration. Dialysis nurses play a pivotal role in dry weight assessment (DW), as they are directly involved with patient treatment and could contribute enormously to better patient outcome. The purpose of this paper is to discuss the clinical relevance of dry weight assessment and to identify and discuss various methods of assessing dry weight in adult haemodialysis patients through comprehensive search of current literature.

Search Strategy

Databases used to search for literature on the topic included CINAHL Plus with full text on EBSCOhost, Evidence-based practice, all OVID EBM reviews-Cochrane DSR, ACP Journal Club, DARE, CCTR, CMR, HTA, and NHSEED; Journals @ OVID full text. Searches were limited to: full text, humans, English language, and publication of less than five years, so as to provide the most up-to-date available evidence.

Dry weight definition

The meaning of DW has always been contentious, as clinicians could not agree on how to clinically define dry weight (Sinha & Agarwal, 2009). Some clinicians define DW as the weight at the end of the dialysis session at which the patient is more likely to develop symptoms of hypotension (Ishibe & Peixoto, 2004). For many (Amato, Hlebovy, King & Salai, 2008; Daugirdas, 2007), the "ideal" dry weight, sometimes referred by clinicians as "target weight" (Twardowski, 2009), is the weight the clinicians hope a patient will be at the end of each HD session, without suffering any of the intradialytic complications associated with intravascular

Author Details: Susana San Miguel, RN, BSN (Phils), Master of Nursing – Clinical Leadership, Graduate Certificate (Renal), Graduate Certificate (Adult Training and Education), is Renal Clinical Nurse Consultant in the Renal Unit at Liverpool Hospital, Sydney South West Area Health Service.

Correspondence to: Susana San Miguel, Renal Unit, Locked Bag, BC 1871, Liverpool 2170 susana.sanmiguel@sswahs.nsw.gov.au

volume depletion. DW and solute removal equates to dialysis adequacy (Amato, et al., 2008). Others define DW based on blood pressure (BP) as the parameter, that is, the absence of hypertension and hypotension (Agarwal, Alborzi, Satyan, & Light, 2009). For some DW is defined as the patient's current body weight in a physiological extracellular volume (ECV) state (Raimann, Liu, Tyagi, Levin, & Kotanko, 2008), that is, the ECV is not expanded. Sinha and Agarwal (2009) has incorporated all these definitions but adding further statement 'how the patient feels' (pp.480).

Fluid compartments – the role of intravascular refilling

Paramount to the understanding of fluid removal and DW assessment in HD is the basic concept of fluid transport between the two major fluid compartments in the body, intracellular and extracellular compartments (Amato, et al., 2008; Raimann, et al, 2008). In a 70kg adult, the intracellular space holds approximately 23 litres of fluid in comparison to 17 litres in the extracellular space, where 5 litres of blood volume is in the intravascular space (Amato, et al., 2008). In between dialysis, when fluid is not being removed, the intravascular space fills-up to a certain capacity. As the patient continues to consume fluid, excess fluid volume spills into the interstitial space where it can hold as much as 20-40 litres (like a sponge), sometimes known as the third space (Amato, et al., 2008). At this point, gross oedema can be observed on the patient.

During haemodialysis, as fluid is removed from the intravascular space, fluid from the interstitial space moves into the intravascular space, known as the plasma refilling rate (PRR) (Amato, et al., 2008; Raimann, et al, 2008). If the PRR is less than the ultrafiltration rate (UFR), that is, fluid in the intravascular space is not being refilled as quickly as it is being taken-off, the patient could suffer from intravascular volume depletion and associated symptoms (Davenport, 2006; Brummelhuis, van Schelven, & Boer, 2008). Factors that could affect the PRR include: low albumin level (to sustain plasma oncotic pressure), congestive heart failure, reduced plasma osmolality, hypoxaemia, ischaemia, septicaemia, fever, autonomic dysfunction, and ingestion of anti-hypertensive medications (Amato, et al., 2008, Raimann, et al, 2008). In this situation, fluid removal and dry weight assessment is a challenge, as the patient would exhibit signs of fluid overload and yet dialysis staff are unable to further reduce the weight. Doing so would result in the patient experiencing intradialytic symptoms, such as hypotension, cramps and dizziness (Davenport, 2006).

Significance of dry weight assessment

Dry weight assessment is crucial in delivering optimal and effective haemodialysis. Several studies have been conducted on the effects of inaccurate assessment or estimation of DW. Hypervolaemia (fluid overload) is the major risk factor in the development of hypertension, left ventricular hypertrophy, and cardiovascular disease thus affecting the mortality risk of patients on haemodialysis (Amato, et al, 2008). Conversely, a DW that is set too low can result in hypovolaemia thus inducing hypotension, cramps, and dizziness (Daugirdas, 2007). Hypovolaemia can also result in reduced blood supply to vital organs causing ischaemia, consequently contributing to the loss of residual renal function (Amato, et al, 2008).

Dry weight and cardiovascular disease

Approximately 36% of the dialysis population die of cardiac-related causes (McDonald, Excell, & Livingstone, 2007). A prospective study of 143 patients on chronic haemodialysis found that the risk of myocardial infarction, coronary artery by-pass graft (CABG) operation or coronary artery dilatation, and death is increased in patients with high (>3%) interdialytic weight gain (IDWG) is highly significant (Holmberg & Stegmayr, 2009). Similarly, a literature review found that high IDWG (>3%) and non-compliance with the treatment, are independent risk factors for higher blood pressure amongst haemodialysis patients (Sarkar, Kotanko, & Levin, 2006).

Dry weight and blood pressure control

A prospective randomised controlled trial of 150 chronic haemodialysis patients found that DW reduction has a positive effect on blood pressure (Agarwal, et al., 2009). However, the incidence of intravascular volume depletion, necessitating fluid resuscitation and ultrafiltration (UF) volume reduction, was commonly seen in the patients receiving the intervention to low DW. In addition, patients in the intervention group had more episodes (n=8) of clotted access as compared to the control group (n=2). This poses the question does reducing DW contributes to clotting of vascular access, despite better BP control? Although this is possible, other factors could have contributed to the higher incidence of clotted access in the intervention group beside DW reduction. For instance, this study has tried to probe DW in the brink of hypovolaemia, which could have contributed in the clotting of access. The clotting of access may have resulted due to poor intravascular refilling and not necessarily due to DW reduction. It is possible that the DW could have been reduced efficiently by increasing the dialysis time to provide adequate intravascular refilling time (Amato, et al, 2008). In this instance, blood volume monitoring could be beneficial in evaluating the refilling status on dialysis (Brummelhuis, et al, 2008; Dasselaar, et al, 2007) whilst assessing the DW and BP.

Dry weight and hypotension

Intradialytic hypotension (IDH) accounts for approximately 20% (Sentveld, Van Den Brink, Brulez, Potter Van Loon, Weijmer, & Siegert, 2008; Amato, et al., 2008) to 40% of HD complications (Davenport, 2006). Causes of IDH are multifactorial. One of the causes of IDH is the inaccurate estimation of DW, that is, DW is set too low (Davenport, 2006; Amato, et al., 2008) leading to poor PRR and consequently volume depletion (Hossli, 2005). IDH requires immediate nursing intervention to prevent further intradialytic complications, such as ischaemia and hypoxaemia (Amato, et al., 2008). Interventions include administration of normal saline, stopping ultrafiltration (UF) and on occasions, early treatment termination. All of these lead to inefficient fluid removal and decrease dialysis dose (Franssen, Dasselaar, Sytsma, Burgerhof, De Jong, & Huisman, 2005). A study on the clinical management of hypotension which involved telephone interviews of 12 dialysis nurse managers, found that the majority of dialysis staff (81%) agreed that frequent occurence of IDH leads to decreased efficiency of dialysis (Hossli, 2005). In addition, although this study found that each IDH episode only took less than 15 minutes to manage, it can be a time-consuming process, and can add additional pressure on the already exhausted staffing capacity of dialysis units.

Methods of DW assessment

Traditionaly, DW assessment is based on trial and error, as patient's weight can change periodically and therefore should be assessed on a regular basis (Daugirdas, 2007). Methods of DW assessments include clinical method such as physical and biochemical assessments (Charra, 2007), and non-clinical methods such as inferior vena cava diameter measurement, blood volume monitoring, bioelectrical impedance, and extravascular lung water index (Ishibe & Peixoto, 2004; Raimann et al, 2008; Sarkar, et al, 2006).

Clinical Methods

DW cannot be assessed in any patient by a single parameter (Purcell, et al., 2004). In order to accurately determine patient's DW, a combination of clinical signs and other parameters are often considered. Clinical assessment has always been the most widely used by dialysis staff in assessing patient's DW (Charra, 2007), as it is relatively easy and quick to perform (Kooman, van der Sande, & Leunissen, 2009). This includes (but not limited to) measurement of jugular venous pressure (JVP), inspecting for signs of oedema (dependent and peripheral), measurement of BP pre and post-dialysis, chest auscultation, assessing skin turgor and mucous membranes inspection (Amato, et al., 2008; Campbell, 2006).

a.) Blood pressure~~s~~ (BP)

BP must be measured sitting and standing, as orthostatic change in BP is a useful diagnostic tool (Charra, 2007). Elevation of the BP, especially if persistent, usually indicates a need to reduce the DW. Conversely, persistent low BP, accompanied by signs of volume depletion such as dizziness, cramping, and vomiting may indicate a need to raise the DW (Charra, 2007). Caution should be exercised before the DW is increased in a patient who has poor cardiac function, since this alone may be responsible for low BP (Agarwal, et al., 2009).

b.)Jugular venous pressure (JVP)

JVP is one useful sign, but unfortunately has been neglected by dialysis nurses and physician (Raimann, et al., 2008). Elevation in the jugular venous pressure is a useful sign of fluid overload and should be performed before the commencement of haemodialysis. Elevation of the jugular venous pressure during or at the end of haemodialysis may indicate a need for target weight adjustment (Raimann, et al, 2008). On the other hand, one must be aware that the mere absence of an elevated jugular venous pressure during haemodialysis or at the end may still be consistent with fluid overload and should not be relied on for assurance that the target weight is appropriate. For example, patients with heart failure may not have elevated JVP, but can still be fluid overload (Ind, 2006).

c.) Presence of oedema

Dependent oedema (i.e. ankles, legs for ambulatory patients, and sacrum for bed-bound patients) is a reliable sign of excess body water (Amato, et al., 2008) and usually means that DW should be lowered. There is also a need to ensure that the serum albumin is high enough to facilitate the movement of interstitial fluid back into the circulation (Charra, 2007). Staff must be aware that some patient may still be overloaded in the absence of oedema, known as 'silent overhydration' (Amato, et al., 2008, p.693). Breathlessness is commonly caused by pulmonary oedema in this patient population, and is often caused by fluid overload or left heart failure or both (Sherman, Daugirdas, & Ing, 2007). Urgent reassessment of DW and of diagnoses other than fluid overload is required (Charra, 2007) so that appropriate treatment could be instituted.

d.) Treatment history

Treatment history should include parameters such as any recent change in target weight and how well the change was tolerated and average IDWG. Dialysis nurses must also note the average pre/post dialysis BP, including postural changes in BP. Other parameters to include in reviewing patient's history include the medications that the patient takes which might affect the BP (such as antihypertensive medications), and whether these are omitted before each dialysis (Purcell, et al., 2004). Dialysis nurses must also note the average fluid volume administered each treatment or the number of saline boluses administered for BP support (Corea, Christensen, & Vogel, 2005). Any recent hospitalisations, holidays and patient's eating habits must also consider, as these could indicate the need for DW adjustment (Amato, et al., 2008). For example, during acute illness, patients have decreased appetite leading to loss muscle mass, necessitating DW reduction, as most of the weight gained would be from fluid accummulation.

Biochemical assessment

a.) Serum albumin

Albumin creates the oncotic pressure in the intravascular fluid compartment allowing for the movement of fluid from interstitial tissue to intravascular space (Amato, et al., 2008). In some patients, fluid removal is not well tolerated if the serum albumin is low, (<34g/L) (Charra, 2007). The patient may show signs/symptoms of decreased blood volume such as hypotension and cramps, despite still being fluid overloaded (Purcell, et al., 2004). It is therefore imperative that clinicians review serum albumin level in combination with other clinical parameters when assessing DW.

Non-clinical Methods

Clinical methods are the most commonly used for DW assessment, although there are some limitations to their use, most specifically physical assessment (Ishibe & Peixoto, 2004). For example, volume overload can be affected by nutritional status and heart function whilst BP can be affected by other factors other than fluid volume (Raimann, et al., 2008). Non-clinical methods can further assist in objectively assessing patient's DW. These methods include:

a.) Inferior vena cava diameter (IVCD) measurement

Inferior vena cava diameter (IVCD) and collapsibility measurement can evaluate the amount of intravascular volume in HD patients, that is, it can detect intravascular volume overload or depletion, and correlates well with central venous pressure (Charra, 2007). This procedure is done through echography of the inferior vena cava diameter, measured in supine position during inspiration and expiration (Ishibe & Peixoto, 2004; Kooman, van der Sande, & Leunissen, 2009; Locatelli, Cavalli, Tucci, Vigano, & Di Filippo, 2009). It can be useful in dry weight assessment in haemodialysis patients in combination with clinical assessment and has been shown to predict haemodynamic changes during dialysis (Kooman, et al, 2009). However, because the IVCD is strongly related to the right atrial pressure, this method is unreliable in patients with right sided heart failure (Kooman, et al, 2009). In addition, the high cost involved in performing the procedure, and the need of timing accuracy in performing the measurement for reliability limits its usefulness in the clinical setting (Kooman, et al, 2009; Raimann, et al., 2008).

b.) Extravascular lung water index (ELWI)

This method uses the thermal dilution technique with the PiCCO system (Pulsion Medical System, Munich, Germany) in IBW assessment (Kuhn, Kuhn, Rykow, & Osten, 2006). It is an invasive procedure as it involves the insertion of an arterial catheter to measure ELWI with the aid of the PiCCO-system. A prospective study of 42 chronic haemodialysis patients who were admitted for elective coronary angiography, found that this method gives a precise fluid volume status in dialysis patients (Kuhn, et al., 2006). Results of this study showed that 28 of 42 patients studied (67%) have elevated values of ELWI, indicating incorrect DW. DW was able to be reduced on these patients without any side effects. In addition, 14 patients who were below their IBW at the beginning of dialysis were found to have elevated ELWI values, and 9 patients had their DW consequently reduced. Although this study has proven the benefit of using ELWI as a tool in assessing DW for dialysis patients, it is an invasive procedure and is only applicable if patient is admitted to hospital and has arterial access. As such, its applicability in everyday clinical practice is limited. In addition, no other studies have been conducted in the use of ELWI for assessing DW amongst dialysis patients.

c.) Blood Volume Monitoring (BVM)

BVM measures the blood density during haemodialysis through an optoelectric device or ultrasound transmitter (Amato, et al.; Kooman, van der Sande, & Leunissen, 2009; Lambie & Warwick, 2007). As fluid is removed from the vascular space during haemodialysis, excess body water from the interstitial space would transfer into the vascular space (vascular refilling). Certain blood constituents, such as red cells and plasma proteins are unable to leave the intravascular space thus making the intravascular solute mass relatively constant even when there are changes in blood volume due to ultrafiltration or refilling (Dasselaar, 2007). Changes in relative blood volume or blood density, through haematocrit percentage, are then progressively measured during haemodialysis. Clinicians then interpret the relative blood volume and haematocrit in comparison to the UFR throughout the entire dialysis time (Dasselaar, de Jong, Huisman, & Franssen, 2007).

Some authors believed that although the BVM is a non-invasive, easy to perform procedure, its main applicability in the clinical setting is to detect blood volume changes during UF and thereby predict IDH (Kuhlmann, Zhu, Seibert, & Levin, 2005). Since, PRR can be influenced by other patient pathologies such as autonomic dysfunction, its usefulness in assessing DW is limited (Raimann, et al., 2008). In addition, other factors such as dialysate sodium can influence the changes in RBV, making BVM limited in the assessment of DW (Kooman, et al, 2009).

In another study of 13 chronic HD patients over 17 weeks, it was found that the relative blood volume and relative blood volume ultrafiltration ratio has considerable differences between the first and third HD sessions, limiting the use of these parameters in preventing IDH and as a tool in DW assessment (Dasselaar, et al, 2007). However, the results of this study indicate that BVM should be utilised to monitor changes in the patients' relative blood volume every dialysis over a 2-week period. This will then enable clinicians to adequately interpret the results by the end of the 2-week period. In most patients, IDWG is expected to be higher after a 2-day break (of dialysis session) compared to 1-day break, hence are unable to reach their DW on their first dialysis day due to limited time (Sarkar, et al, 2006). If the patient's relative blood volume remains unchanged over the 3 consecutive haemodialysis sessions, that is, the relative blood volume graph is greater than 95% at the end of each dialysis, then the patient still has a lot of interstitial fluid on board, hence DW should be slowly reduced. If patient's relative blood volume continues to decrease towards the end of the week, then the patient is reaching their DW (Dasselaar, et al, 2007).

The importance of intra and inter-individual variability was further highlighted in a pilot study of 12 chronic stable patients on HD (Zellweger, Querin, & Madore, 2004). This study found that although BVM is a useful and safe tool to adequately achieve patients' DW, nurses must be aware that each patient can respond differently (in regards to relative blood volume changes) at different dialysis sessions. Critical analysis of the BVM graph is essential to utilize this method effectively in assessing patient's DW (Dasselaar, et al, 2007). In addition, BVM results must always be analysed together with other clinical parameters such as blood pressures, albumin levels, and most of all how the patient feels before and after haemodialysis. Lindley (2006) points out that the use of BVM in assessing DW requires dialysis nurses to take into account the whole patient, and not just rely on the technology.

Furthermore, Lopot, Nyiomnaitham, Svarova, Polakovic, Svara, & Sulkova, (2007) argued that BVM can be useful in determining DW by analysing how patient responds with different UF profile and varying degrees of hydration for each dialysis session. The authors further stated that for BVM to be used for DW assessment the following methods must be used in the analyses of relative blood volume: (1) a relative blood volume that does not decrease during haemodialysis despite constant UFR, signifies over-hydration hence DW should be reduced; (2) a relative blood volume that decreases during treatment but refilling is seen after UF cessation and patient is symptomatic of intravascular depletion is mainly due to insufficient refilling time. In this instance, DW can still be decrease but dialysis time is increase, to allow sufficient time for refilling of intravascular space; (3) a decreasing relative blood volume during haemodialysis without refilling after UF cessation, and symptom-free dialysis indicates that the patient is on the correct DW and should be maintained (Lopot, et al, 2007).

d.) Bioelectrical Impedance Analysis (BIA)

Bioelectrical impedance assesses the total body water component, that is, extracellular and intracellular fluid volume. It is very useful in determining fluid status in all body compartments making it an ideal tool in assessing DW (Jain & Lindsay, 2008). This method has been used for the last 30 years for fluid assessment and various methods of Bioelectrical impedance analysis have evolved, such as whole body, segmental, single frequency and multi-frequency bioelectrical impedance (Raimann, et al., 2008). Several studies have investigated the validity of this method in IBW assessment. In a study conducted by Ishibe & Peixoto (2004) utilising this method for dry weight assessment, have resulted in dry weight reduction of 121 patients and better blood pressure control. Another randomised controlled trial, used bioelectrical impedance analysis in the assessment of percentage of total body water content, in combination with blood volume monitoring (Nesrallah, Suri, Thissen-Philbrook, Heidenheim, & Lindsay, 2008). Although this study was not able to achieve its primary end-point of reducing extracellular fluid volume, the intervention group had decreased episodes of IDH.

In a comparison study of 6 conventional and 5 daily haemodialysis patients, segmental BIA was used to analyse the intra and extra cellular fluid shifts during and after haemodialysis (Jain & Lindsay, 2008). This study found that there was a continuous reduction of extracellular fluid from lower extremities as compared to the trunk, on both groups at 24 hour measurement, emphasising that fluid removal during dialysis occurs mainly from the extremities, rather than the trunk compartment to preserve central blood volume. This may account for patients experiencing cramps on the extremities during fluid removal, despite being fluid overloaded. Although this study has shown that segmental BIA is a reliable method of DW assessment, the sample size on this study is small (n=11) and were not randomly selected. A larger randomised controlled trial using this technology would be beneficial in determining the reliability of this method.

Conclusion

DW assessment in haemodialysis is crucial to prevent the short and long-term side effects of inaccurate DW. New technologies in DW assessment are now available as an added tool for the clinicians to use. Although these technologies have assisted some clinicians in managing effective fluid removal and DW assessment, the validity and clinical applications of these have been limited. This is because of the cost involved or the lack of randomised-controlled trial to examine its usefulness in the clinical setting. In addition, most of the studies presented in this literature review were conducted by Medical Professionals, and yet dialysis nurses are on the forefront of patient care. We have the expertise and knowledge to accurately assess patients' DW and are the primary users of new dialysis technology. Dialysis nurses should take a leadership role in initiating quality projects that would enhance and improve patient care delivery and positive outcomes. Although clinical method is the most commonly used method by dialysis nurses in assessing DW, it is important to note that this does not only include physical assessment, but rather a comprehensive review of other parameters such as blood results, medications and treatment history. A comprehensive review can be a lengthy process in the beginning but it is a worthwhile effort in preventing deleterious consequences for the patient. In dialysis facilities that have the opportunity to use these new technologies, such as BVM or BIA, clinical leaders must ensure that clinicians are confident enough to use these in combination with clinical methods in dry weight assessment.

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