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## Setting the Dry Weight and Its Cardiovascular Implications

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### Abstract

Volume overload is common and associated with adverse outcomes in the hemodialysis population including systemic hypertension, pulmonary hypertension, left ventricular hypertrophy, and mortality. Prescribing and maintaining a dry weight remains the standard of care for managing volume overload on hemodialysis since the start of the chronic dialysis era. Reducing dry weight even by relatively small amounts has been shown to improve blood pressure and has been associated with reductions in left ventricular hypertrophy. Maintaining an adequately low dry weight requires attention to sodium intake and adequate time on dialysis, as well as a high index of suspicion for volume overload to be treated with reduction in dry weight. Reducing dry weight can provoke decreased cardiac filling and is associated with risks including intradialytic hypotension. The ideal method to minimize intradialytic morbidity is unknown, but more frequent dialysis should be considered. Experimental methods of assessing volume status may allow identification of patients most likely both to tolerate and to benefit from dry weight reduction, but further study is needed.

### Keywords

hypertension; blood pressure; dialysis; epidemiology; dry-weight; volume status; ambulatory blood pressure monitoring; randomized controlled trials

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The purpose of renal replacement therapy is to replace the vital functions of the failing kidneys. While the kidneys have important endocrine and hematopoietic functions, in practice renal replacement therapy is focused on restoring the extracellular milieu via dialysis. Chronic dialysis has two primary long term functions: clearing uremic solutes via diffusion and removing volume via ultrafiltration (UF). The uremic toxins have not yet been identified (1) but uremic solute clearance is assessed by measuring the clearance of a surrogate, urea. Adequacy of urea clearance is now routinely measured and is a cornerstone of chronic maintenance dialysis practice. Since the inception of the chronic dialysis era in the 1960's the importance of volume removal via UF has been recognized, but there remains no objective measure of adequacy of volume removal akin to the Kt/V for urea clearance, so the dry weight method remains the standard of care for treating volume overload on dialysis.

This review will cover the consequences of volume overload, the method of managing volume control via the dry weight method, obstacles to maintaining euvolemia, and finally future directions for dry weight management.

## Importance of Volume Control

The deleterious consequences of volume overload are manifold and include hypertension, left ventricular hypertrophy (LVH), hospitalization, and mortality. Volume overload causes hypertension in dialysis patients both via increased cardiac output and increased systemic vascular resistance (2). Up until the 1960's malignant hypertension was common in patients with end stage renal disease (ESRD), but since the dawn of the chronic dialysis era UF has been recognized as an effective means of BP control in ESRD (3) starting with the first chronic HD patient in the United States, a man named Clyde Shields under the care of Dr. Belding Scribner (4). However it's only been recently that a randomized controlled trial confirmed those original observations with the report of the Dry Weight Reduction in Hypertension Hemodialysis Patients (DRIP) trial (5).

The DRIP trial recruited 150 chronic and stable HD patients on an average of 2.6 antihypertensive medications with uncontrolled hypertension confirmed by 44 hour interdialytic ambulatory BP monitoring and those subjects were then randomized to intervention versus usual care for the 8 week trial. All subjects had their antihypertensive medications and their prescribed time on HD kept stable. The intervention group received progressive reduction in dry weight by at least 0.2 kg each HD session until they had symptoms of hypovolemia while the control group had their prescribed dry weight left unchanged. Compared to the control group at 8 weeks, the intervention group weighed an average of 1 kg less and had an average reduction in 44 hour interdialytic ambulatory BP of 6.6/3.3 mmHg.(5) Importantly, by protocol, those subjects in the intervention group had to experience signs of hypovolemia before dry weight reduction was stopped, yet despite this design there was no change in any domain of the Kidney Disease Quality of Life questionnaire during the trial.

In addition to systemic hypertension, pulmonary hypertension has also been associated with volume overload in ESRD patients. While the prevalence of pulmonary hypertension is low at only around 5% in the general population, it is much higher at 25% in the setting of CKD 5 and up to 40% in the HD population (6). The Prevalence of Precapillary Pulmonary Arterial Hypertension in Patients with ESRD (PEPPER) study investigated the causes of pulmonary hypertension by recruiting 31 patients with ESRD on HD and with unexplained dyspnea but without comorbidities including uncontrolled systemic hypertension, reduced left ventricular ejection fraction, valvular heart disease, or chronic obstructive pulmonary disease (7). All subjects had right heart catheterization before and after HD, and of the 31 subjects 24 (77%) had pulmonary arterial hypertension defined as mean pulmonary artery pressure  $\geq 25$  mmHg even after HD. Notably, while the overall mean pulmonary capillary wedge pressure (PCWP) fell significantly after HD, only 4 subjects had PCWP  $\geq 15$  mmHg after HD thus suggesting persistent volume overload was the cause of the pulmonary hypertension in 20 of the 24 subjects (7).

Both pressure and volume overload lead to LVH in the HD population (8) with a prevalence of LVH as high as 75% in patients initiating HD (9). Strict attention to volume control has been associated with reduced LVH retrospectively (10), and clinical trial results suggest dry weight reduction is associated with improved echocardiographic LVH in both the short (11) and long term (12), though these studies require replication.

Hospitalizations are common for HD patients with an average of 1.7 hospital admission per year (13), and volume overload is a major contributor. An analysis of Medicare data found a 14% yearly rate for hospitalization or emergency room visit requiring acute HD for volume overload costing Medicare over \$100 million per year (14). Similarly, after an index hospitalization for congestive heart failure (CHF), patients die or are rehospitalized within 30 days 40% of the time (13).

Mortality remains high in the HD population with a 5 year survival rate at 40% (13), worse than for stage III C colon cancer (15), despite copious resources devoted to HD totaling \$26 billion from Medicare in 2014 for HD alone (13). There are many putative causes for this excess mortality in the HD population, but volume overload is undoubtedly a factor; indeed, CHF is listed as the primary cause of death in 5% of ESRD patients (13).

Further evidence for the contribution from volume overload is found in the form of two prospective studies using investigational methods to measure volume status. The first recruited 269 HD patients and performed bioimpedance analysis at baseline before assessing for mortality at 42 months of follow up (16). They found volume overload by bioimpedance criteria is an independent risk factor for mortality, a finding that persisted after adjustment for pre or post-dialysis BP. The second study recruited 308 HD patients and performed relative plasma volume monitoring (often known by the trade name CritLine) at baseline and followed the subjects for a median of 30 months (17). Similarly, they found that volume overload by their criteria also is an independent risk factor for mortality, which persists even after adjustment for ambulatory BP, UF volume, or UF rate. Thus two decently sized prospective studies utilizing fundamentally different objective methods to assess volume status both found significantly increased mortality risk for volume overload despite adjustment for BP. This is an important reminder that while volume overload and hypertension are related they are not synonymous.

## Definition of Dry Weight

In order to manage volume overload the typical HD prescription includes a dry weight, which is used to calculate the UF goal for any given HD session. However, while providers and patients on dialysis all typically have a sense of what dry weight means, there remains no consensus on its precise definition. The earliest definition of dry weight in the literature is from the late 1960's stating that achieving dry weight will provoke "reduction of blood pressure to hypotensive levels during ultrafiltration and unassociated with other obvious causes (18)." Rather than defining the dry weight as the target post-dialysis weight that reliably provokes intradialytic hypotension, dry weight has also been defined as "the weight obtained at the conclusion of a regular dialysis treatment below which the patient more often than not will become symptomatic and go into shock (19)."

In contrast to the prior two definitions that rely on bringing the patient to hypotension or close to shock, a more recent definition of dry weight is “that body weight at the end of dialysis at which the patient can remain normotensive until the next dialysis despite the retention of salt water,” and ideally without antihypertensive medications (20). Our preferred definition of dry weight is the following: the lowest tolerated post-dialysis weight achieved via gradual change in post-dialysis weight at which there are minimal signs or symptoms of either hypovolemia or hypervolemia (21).

Three features of our definition deserve special attention: gradual change, tolerability, and minimal symptoms as a threshold. Prioritizing a *gradual change* in post-dialysis weight helps to avoid the scenario where large and aggressive changes in post-dialysis weight provoke symptoms that lead both the nephrologist and patient to decide that further reductions in post-dialysis weight will be unsuccessful, which for some patients can be a lifelong conviction. Additionally, planning for a gradual change in post-dialysis weight will require frequent reevaluation by the nephrologist and attention to the patient's symptoms, which will build rapport with the patient and hopefully reduce resistance to future reductions in dry weight if indicated.

By emphasizing the *tolerability* of the dry weight we aim to remind providers that the prescribed dry weight isn't an immutable physical constant such as the patient's height, but rather the lowest achievable dry weight at any given time is contingent on many factors including interdialytic weight gain (IDWG), changes in body composition due to intercurrent illness, or the dialysis modality such as thrice weekly in-center dialysis versus short daily hemodialysis. It is for this reason that we are in favor of the common practice of using the term estimated dry weight because this serves as a constant reminder of the imprecision and iterative nature of the dry weight method.

Lastly, the emphasis on targeting *minimal signs or symptoms* of hypovolemia or hypervolemia is meant to be a departure from the goal of targeting the complete absence of signs or symptoms. For instance, raising the prescribed dry weight repeatedly in an effort to eradicate cramping completely should not be a goal of dry weight management because some patients may always have cramping on HD regardless of how high the dry weight has been set.

## Management of Dry Weight

Managing volume overload in chronic HD is a multidisciplinary effort that requires complimentary strategies to both reduce sodium intake and to augment sodium removal. The former includes dietary sodium restriction and individualization of the dialysate sodium while the latter includes dry weight reduction, providing adequate time on dialysis, and considering frequent dialysis.

The archetype for this holistic management of volume overload is reported by investigators from Tassin, France where patients are dialyzed for extended hours on a low sodium dialysate and low sodium diet is emphasized to the extent that low sodium bread is provided to patients (22). They report excellent control of BP despite antihypertensive medication use

being rare at only 1-2% (23), as well as low mortality with a 5 year survival rate reported at 87% (24), more than twice the rate in the United States (13). Other investigators have reported positive outcomes with a similar holistic approach, including a trial of low sodium diet and dry weight reduction in 19 hypertensive HD patients with a before-after design that resulted in reduced echocardiographic LVH (10). Diligent attention to minimizing sodium intake and providing adequate time on HD are both necessary to set the stage for successful dry weight management.

## Minimize Sodium Intake

Minimization of sodium intake is a vital component of dry weight management. In the HD patient an increased dietary sodium load leads to increased IDWG (25) which then requires increased UF rates, both of which are associated with cardiovascular mortality (26;27). Restricting dietary sodium intake reduces IDWG, which will also practically improve the ability to achieve an adequately low dry weight with HD (28;29). The American Heart Association recommends < 1,500 mg (equivalent to 65 mmol) daily intake (30), which is a reasonable prescription for dialysis patient (31) and one that we make to our patients. Notably except for treating hyponatremia, there is no rational role for fluid restriction in dialysis patients (25;32). Furthermore, implementing a fluid restriction can distract from the vitally important sodium restriction among patients that are already under a significant burden of numerous dietary restrictions and polypharmacy (33).

In the early days of chronic HD low dialysate sodium concentrations were used and thus sodium removal on HD was due both to diffusion as well as convective removal with ultrafiltration. As the efficiency of dialyzers improved and HD times were reduced, higher dialysate sodium concentrations became the norm to reduce hemodynamic instability, cramping, and symptoms of disequilibrium (34) and initial studies suggested that hypertension wasn't a complication (35). More recently it has been recognized that higher dialysate sodium concentrations will reduce or reverse the diffusive removal of sodium on HD, which undermines the effective management of dry weight (36). In an example of the impact of dialysate sodium concentration, a pilot study reduced dialysate sodium from 137.8 to 135.6 mmol/L stepwise over 7 weeks; net sodium removal was significantly increased from 383 mmol to 480 mmol per HD session (37).

Numerous studies have shown IDWG to be directly related to dialysate sodium concentration with higher dialysate sodium leading to higher IDWG (38-40). Increased IDWG is also seen with sodium profiles, also called sodium ramping, where the dialysate sodium concentration generally starts high and then is gradually reduced during the HD session (39;41;42). While higher dialysate sodium concentrations are prescribed to promote hemodynamic stability, the resulting higher IDWG can lead to higher UF rates which lead once again to hemodynamic instability. Additionally, more recent studies of higher dialysate sodium concentrations, whether constant or with a profile, have been associated with higher BP in some (41;42), but not all investigations (40).

To avoid the vicious cycle above an alternative option is to individualize the dialysate sodium prescription to the patient's pre-HD serum sodium. The importance of

individualization is illustrated by a cross sectional study of over 1,000 HD patients that examined the difference between the individual dialysate sodium concentration and the patient's pre-HD serum sodium and found that this difference is directly related to IDWG, with a higher dialysate sodium concentration relative to the pre-HD serum sodium being associated with greater IDWG (43).

A single-blind crossover study of 27 HD patients illustrated one method of individualizing the dialysate sodium concentration. All patients were first dialyzed with a standard 138 mmol/L sodium dialysate for 3 weeks and then on a dialysate sodium concentration set to 0.95 multiplied by the pre-HD serum sodium for 3 weeks (44). On the low sodium dialysate prescription significant reductions were seen in IDWG (by 0.6 kg), the frequency of intradialytic hypotension, and the pre-HD SBP for hypertensive subjects. Based on these findings it is reasonable to recommend that dialysate sodium be individualized to avoid being higher than the individual patient's pre-HD serum sodium and possibly as low as 0.95 multiplied by the serum sodium in hypertensive individuals or those with high IDWG, the latter of which will often preclude the achievement of an adequately low dry weight.

### **Provide Adequate Time on Dialysis**

The prescription of adequate HD treatment time is a critical component of managing dry weight. Sufficient time on HD not only ensures adequate time to achieve uremic solute removal but also adequate time for UF, whereas shortening prescribed HD time will lead to higher UF rates and possibly to more intradialytic hypotension or symptoms that will prevent the achievement of an appropriately low dry weight. For example, a randomized crossover trial of 38 HD patients investigated the effect of time on HD by assigning subjects to 2 weeks of 4 hour versus 5 hour HD sessions and found significantly less intradialytic hypotension and post-HD orthostatic hypotension during the longer HD runs (45). Similarly, a recent secondary analysis of the DRIP trial found shorter HD times to be associated both with higher BP and slower improvement in BP when dry weight is reduced (46). An added salutary effect of longer HD time is that for a given amount of IDWG, an increased HD time will lead to a lower UF rate, which has been associated with reduced mortality (27).

It is for all these reasons that the European Best Practice Guidelines recommend that HD should be delivered at least three times weekly for a total duration of at least 12 hours, unless substantial residual renal function remains (47); we adhere to this standard in our own practice. However, in the United States a recent cohort study among 32,000 HD patients found that the average single HD session was only 217 minutes and that one quarter of patients dialyzed less than 3 hours and 15 minutes per session (48). The lower average treatment times in the United States are likely due to the practice of reducing the prescribed time to achieve a minimum goal Kt/V. This practice should be avoided due to its downside effects on volume status and hypertension (49).

### **Dry Weight Reduction**

When deciding whether to adjust the dry weight prescription, the first step is to assess for volume overload. The routine clinical exam performs well at detecting acute or massive

volume overload but is insensitive for detecting subtle and chronic volume overload (21). For example, a cross sectional study of 150 chronic HD patients found the presence of pedal edema to have no correlation with objective markers of volume overload including B type natriuretic peptide, echocardiographic inferior vena cava diameter, or relative plasma volume slope (50). As another example, it is important to consider that all the hypertensive subjects of the DRIP trial were at their clinical dry weight as determined by their primary nephrologist at the start of the trial, yet the subjects of the intervention group had their dry weight successfully reduced by 1 kg, which resulted in a clinically significant improvement in 44 hour ambulatory BP (5). Other trials of dry weight have shown similar results; subjects putatively at clinical dry weight received the trial interventions resulting in average dry weight reductions of 0.7 to 1 kg with associated improvements in BP and LVH (12;51;52). These trial findings illustrate both the difficulty in detecting subtle volume overload but also the clinical importance of small changes in the prescribed dry weight of around only 1 kg.

Since even mild volume overload can be hard to detect yet also be clinically important, it should be the duty of treating nephrologist to maintain a high index of suspicion for occult volume overload. Signs that should prompt consideration for reduction in dry weight include uncontrolled hypertension, especially in those patients who are on multiple medications such as in the DRIP trial where subjects were on an average of 2.6 antihypertensive drugs at baseline (5). Numerous studies have shown that greater antihypertensive drug use is associated with worse control of hypertension (53;54), which is plausibly due to inadequately addressed volume overload.

Another sign that should prompt consideration for reduction in dry weight is low IDWG. This comes from the observation that IDWG tends to rise when dry weight is reduced and IDWG tends to fall when volume overload increases (55). As further evidence, a secondary analysis of the DRIP trial employed relative plasma volume monitoring to gauge volume status and found the quartile with greatest volume overload to have the lowest IDWG at baseline (56). More importantly, subsequent reduction in dry weight per the trial protocol in this quartile with the lowest IDWG resulted both in the greatest weight loss at 1.5 kg and in the greatest reduction in 44 hour ambulatory SBP at 12.6 mmHg. Thus low IDWG may be a sign of occult volume overload and low IDWG should not be considered to be synonymous with euvolemia (57). Lastly, as a practical matter, a low IDWG also makes it easier to successfully challenge below the current prescribed dry weight.

It is important to note that while volume overload is a major contributor to hypertension in ESRD and volume removal is the foundation of hypertension control in ESRD, hypertension and volume overload are not equivalent. Stated another way, the absence of hypertension doesn't definitively rule out the presence of volume overload. This is illustrated by a study of 500 HD patients using bioelectric impedance that found 33% of the cohort to be euvolemic and normotensive based on BP before and after HD, while 10% were volume overloaded yet still normotensive, and 13% were euvolemic but still hypertensive (58).

The distinction between hypertension and volume overload is even more important when outcomes are considered. Volume overload is independently associated with mortality both when assessed by bioelectrical impedance (16) and by relative plasma volume monitoring

(17), findings that persist even after adjusting for BP in both studies. So while the presence or absence of hypertension is an important finding to guide the clinical assessment of volume status in dialysis, the treating nephrologist must keep an open mind and look for other signs of volume overload.

When reducing dry weight, we recommended decrements as small as 0.2 to 0.3 kg per HD session based on the recognition that even small changes in dry weight can be clinically significant, as dry weight reductions of 0.7 to 1 kg have been associated with reduction in BP and LVH in trials (5;12;51;52). An added benefit of making small and gradual changes in dry weight is that it builds trust in patients who are often reluctant to permit their dry weight to be lowered for fear of provoking symptoms such as cramping.

Achieving and maintaining an adequately low dry weight is a hands-on and iterative process that requires vigilant attention to details beyond only the prescribed dry weight(59). These include adherence to a low sodium diet, minimization of dialysate sodium content, and providing adequate time on HD all of which combine to provide the environment where the dry weight can successfully be reduced when needed.

## Risks to Dry Weight Reduction

As with any medical intervention there are risks to challenging dry weight, and a paradigm where dry weight is routinely challenged to treat subtle but clinically significant volume overload would be expected to increase the frequency of those risks. All the UF removed during an HD session comes from the intravascular space; a UF volume of a few liters represents a substantial portion of the total blood volume making it perhaps surprising that intradialytic hypotension doesn't occur during every HD session. The obvious explanation is that while the UF volume comes from the intravascular space, refilling occurs from the interstitial space into the intravascular compartment and the net effect is a reduction in total extracellular volume. When the UF rate exceeds the intravascular refill rate the intravascular volume will drop, which if continued would be expected to lead to decreased cardiac filling and reduced cardiac output, and ultimately intradialytic hypotension. This effect was illustrated by a study of 10 HD patients invasively monitored with right heart catheterization over 3 HD sessions. The study found that right atrial pressure, pulmonary artery pressure, and cardiac index all dropped significantly during episodes of intradialytic hypotension and rebounded soon thereafter with saline infusion, while total peripheral resistance remained unchanged in the study (60).

While tachycardia would be an expected result of decreased cardiac filling, bradycardia is a paradoxically common observation during episodes of intradialytic hypotension. As an example, an elegant study of 23 patients on HD demonstrated decreases in heart rate, muscle sympathetic nerve activity, and vascular resistance during episodes of intradialytic hypotension (61). This finding is plausibly explained by the Bezold-Jarisch reflex, a cardioinhibitory reflex characterized by hypotension in conjunction with bradycardia and vasodilation (62). The vagal nerve serves as the afferent pathway for this reflex, and it has been associated with chemical stimuli and inferior myocardial infarction, as well as volume depletion severe enough to cause the vigorous contraction of a relatively empty left



ventricle. Thus decreased cardiac filling can lead to a chain of events culminating in reduced peripheral resistance and bradycardia.

Intradialytic hypotension is ideally avoided because it has been associated with myocardial stunning (63) and increased mortality(64). However, additional risks to challenging dry weight also include increased clotting of vascular accesses (65) and accelerated loss of residual renal function (66).

## Persistent Intradialytic Morbidity

One common scenario is that of a patient whom the nephrologist believes to be volume overloaded, yet who also has intolerable intradialytic morbidity including painful cramping or intradialytic hypotension. In this scenario reducing the dry weight would reasonably be expected to worsen the intradialytic morbidity. Ideally the initial steps should be to reduce IDWG by reducing the prescribed dialysate sodium and counseling the patient on low sodium diet. But if the patient's typical IDWG is already low and time on HD cannot be extended in an effort to reduce UF rate, then an additional option is to consider a change in modality to more frequent dialysis. Observational studies have shown frequent HD is associated with reductions in BP despite lower antihypertensive drug use (67;68), as well as with improvements in LVH (68).

More recent randomized trials have confirmed some of these findings with a trial of 52 patients that assigned subjects to either conventional 3 times weekly HD versus 6 nights weekly nocturnal HD for 6 months and found significantly reduced BP, lower antihypertensive drug use, and improved LVH in the nocturnal HD group (69). The subsequent Frequent Hemodialysis Network (FHN) Nocturnal trial recruited 87 HD patients and randomized them to 3 times weekly conventional HD versus 6 nights weekly nocturnal HD, and weekly average pre-HD BP was significantly improved in the nocturnal HD group despite a reduction in antihypertensive medication use; however the trends toward improvement in the primary endpoints including LVH were nonsignificant, possibly due to lack of power from difficult subject recruitment (70). The companion FHN trial of daily HD recruited 245 patients who were randomized to 3 times weekly conventional HD versus 6 days weekly HD for 12 months. This trial of daily HD did find significantly reduced hazards for both coprimary composite endpoints of death or increase in left ventricular mass and death or decrease in the physical-health composite score (71). Both weekly average pre-HD SBP and the number of antihypertensive medications were significantly reduced in the intervention group. These improvements in BP and LVH are plausibly due to better control of volume overload (72), since the daily HD group had significantly more ultrafiltration per week at 10.6 L versus only 9.0 L for the control group (71).

## Future Directions

Currently, management of dry weight to minimize even subtle volume overload requires both maintaining a high index of suspicion for occult volume overload and frequently probing the dry weight, but this paradigm necessitates the willingness to provoke intradialytic morbidity with its associated risks in patients who may not benefit. Large long

term randomized controlled trials are necessary to adequately assess the balance of risks versus benefits for this strategy of volume control, but unfortunately no such trials are available to date.

One active area of research is in the field of experimental objective measures of volume status that may more reliably identify those patients who would tolerate and benefit from dry weight reduction. Such investigational measures include natriuretic peptides, inferior vena cava diameter, relative plasma volume monitoring, and bioelectrical impedance analysis (73). The latter two methods have the most supporting evidence with a secondary analysis of the DRIP trial showing that those subjects identified as most volume overloaded by baseline relative plasma volume monitoring subsequently under protocol for dry weight reduction had the largest reduction in weight at 1.5 kg and the largest improvement in ambulatory SBP at 12.6 mmHg (56). More recently, a randomized trial of bioelectrical impedance analysis to guide dry weight management in a cohort of largely normotensive HD subjects found a significant improvement in LVH as well as improvement in peridialytic BP despite reductions in antihypertensive drug use for the intervention group (12). While these objective measures of volume status are preliminarily promising, they remain investigational and larger validation studies are necessary before their routine use can be recommended.

## Conclusion

Volume overload is common, costly, and associated with poor outcomes in patients with ESRD on HD including systemic hypertension, pulmonary hypertension, LVH, and mortality. There remains no objective measure to assess adequacy of volume removal on HD analogous to the Kt/V used for adequacy of solute clearance, so the dry weight method remains the standard of care for volume management in chronic HD. Reductions in dry weight have been associated with improvements in BP and LVH, and even small reductions are associated with clinically significant improvements. The clinical exam is insensitive to detect subtle volume overload and since even small changes in dry weight may be clinically important, the dialysis practitioner must maintain a high index of suspicion for volume overload that may improve with gradual, iterative reduction in dry weight. Successful management of dry weight requires vigilant attention to low sodium diet, low dialysate sodium concentrate, and adequate prescribed time on HD. Adequately powered long term randomized trials remain needed to balance the benefits with the risks of aggressive dry weight management including intradialytic hypotension.

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