Prescribing Home Hemodialysis

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Home hemodialysis (HHD), performed more frequently than in-center hemodialysis, is underutilized in the United States but has had a recent resurgence driven predominantly by innovative dialysis equipment that is easy to use, less intrusive to the home, and requires less storage space. There are 3 different hemodialysis machines approved for use in the home but currently NxStage™ accounts for the overwhelming majority of HHD patients. Therefore, it is the focus of this article. To minimize storage space in the home, the NxStage platform minimizes the volume of dialysate that is used per treatment. We refer to this method as the Frequent Low Dialysate Volume Approach (FLDVA). The approach to urea removal with the NxStage platform is much different compared to traditional in-center HD. To minimize the volume of dialysate per treatment, and still achieve target urea removal, the dialysate must be highly saturated. In this article, we explain how to increase the saturation of dialysate fluid. We also draw a parallel between urea removal in peritoneal dialysis and NxStage therapy and use that model to estimate an initial HHD prescription and to alter prescriptions when necessary.

Key Words: Home hemodialysis, Frequent low dialysate volume approach, Short daily hemodialysis

Short daily hemodialysis (SDHD) performed 4-6 times/week offers several advantages over conventional thrice-weekly hemodialysis (HD) (Table 1).[1-7] Home hemodialysis (HHD) has enjoyed a modest resurgence in popularity over the past few years and now represents the therapy utilized by 2% of the end-stage kidney disease population in the United States.[8] The revitalization of HHD in the United States over the last 15 years was driven predominately by innovative dialysis equipment developed by NxStage®.[9] Therefore, although there are different options to prescribe HHD, we are emphasizing the use of the NxStage platform for frequent (even daily), usually short session length, low dialysate volume (DV) HD. Most of the other HD platforms work at least prescriptively like current in-center HD and will be applicable to the concept of SDHD. However, because of the novel approach to dialysis prescription and the current market influence of the NxStage platform, we discuss its utilization and how to prescribe it. We will herein refer to SDHD as practiced using the NxStage platform as the Frequent short-duration Low Dialysate Volume Approach as **FLDVA**

PLATFORMS FOR HHD

Currently, the 3 HD platforms approved for use in the home include NxStage System One™, Fresenius 2008K@home, and the Tablo™ Hemodialysis System (approved in March, 2020). The NxStage system has a specific approval for nocturnal dialysis and does not require a partner. The overwhelming majority of HHD patients (~98%) in the United States use the NxStage platform and therefore it has become almost synonymous with HHD.

The approach to fluid removal is similar for all 3 HHD machines. The approach to adjust solute removal for the Fresenius 2008K@home is the same as for in-center HD. The Tablo system is also similar to in-center HD except the maximum dialysate flow rate is 300 mL/minute. Higher blood and dialysate flow rates will increase urea removal. The Fresenius machine requires a separate water treatment system. The Tablo machine has an integrated water purification system and provides dialysate on demand. Electrolyte management is addressed the same as in-center HD by adjusting dialysate sodium, bicarbonate, potassium, and calcium concentrations.

The NxStage dialysis platform is designed to be portable, easy to use, less intrusive to the home environment, and requires less storage space than conventional HD equipment. It is easy to assemble, disassemble, and use without major home plumbing or electrical modifications. The strategy to minimize storage mandates efficient utilization of low DVs. In the first NxStage iteration, bagged dialysate was shipped to homes similar to peritoneal dialysis (PD).[9] Table 2 is a list of those available dialysate bags of differing composition. A major breakthrough was the technology to manufacture in the home ultrapure dialysate from concentrate, precluding bulk water shipments. Dialysate is generated by the PureFlow SL™ system in Saks of differing electrolyte compositions and volumes, as listed in Table 3.

PATIENT-CENTERED AND SOLUTE KINETIC APPROACHES TO HHD

Our attitudes and practice applications for HHD evolved. In 1978 all home HD was performed by the patient and close family member or friend (the care partner), hereafter referred to as the "at home" team. Standard equipment identical to that in-center was used in the home. Often major home modifications were required. We followed rigid policies and procedures. This was a successful endeavor but soon devolved because of the commercialization of

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dialysis. Many local dialysis facilities were opened. The at home teams and their dialysis providers drifted to in-center HD because of convenience, security, and financial incentives. Home dialysis became dominated by PD until the appearance of the NxStage short daily low DV platform.[9]

Successful HHD is a consequence of an interdisciplinary dialysis team, consisting of technicians, social service, dieticians, subspecialty HHD nurses, physicians, and the "at home" team. There is a close collaborative relationship such that the prescription is appropriate, situationally specific, and flexible. Our prescriptive approach is influenced by our experiences with PD, continuous renal replacement therapy, prolonged intermittent renal replacement therapy, Home Dialysis University, KDOQI, and KDIGO.

We base our HHD prescription around the critical aspects of the at home team's lifestyle. The key player on that team is the patient. If the patient is the sole participant, the lifestyle accommodations are less complex. If several care partners are involved (eg, spouse and another), complexity increases. The lifestyle parameter of prime importance is the frequency of the dialysis sessions. This could vary from 2 to 6 times/week and may even be variable week to week. Some patients elect to use a combination of short daily and long nocturnal treatments. All subsequent prescriptive indices will depend on frequency. Not only is frequency dependent on lifestyle and care partner availability but it is also dependent on patient behavior, especially compliance with dietary restrictions. Another patient-specific factor that affects frequency is tolerance to ultrafiltration. Comorbidities, residual kidney function (RKF), responsiveness to diuretics, and dietary compliance influence ultrafiltration tolerance. On occasion, tolerance may be related to the absolute amount of fluid removed but most typically relates to the rate of removal (UFR). If tolerance is poor and the sessions are infrequent, prolonged therapy per session is necessary such as thrice-weekly long slow nocturnal HD. Alternatively, more frequent (daily) shorter duration treatments will be necessary.

Table 1. Advantages of Frequent Short Session Duration Hemodialysis

Improved Quality of Life
Fewer intradialytic symptoms (hypotension, nausea, vomiting)
Shorter postdialysis recovery time
Less postdialysis fatigue
Improvement in restless legs syndrome
Less depression
Improved cardiovascular outcomes
Better blood pressure control
Regression of LVH
Increased EF
Improvement in sleep apnea
Improved phosphate control

CLINICAL SUMMARY

- Novel dialysis equipment that is small, portable, and easy to use is essential for patient utilization of home hemodialysis.
- NxStage is the predominate dialysis machine currently used in the United States.
- To minimize storage space, low volumes of highly saturated dialysate are required.
- This article reviews the novel approach to dialysis prescriptions used for NxStage therapy; we demonstrate how to estimate an initial short daily hemodialysis prescription and how to adjust the prescription when necessary.

VOLUME HOMEOSTASIS

Volume overload and its attendant adverse effects are common in dialysis patients. Unfortunately, vigorous volume removal is deleterious as well. Studies have demonstrated that a UFR >10 mL/kg/hr is associated with increased cardiovascular mortality.[10] This is likely due to changes in myocardial blood flow creating regional wall motion abnormalities, referred to as cardiac "stunning". Daily HHD, with more frequent removal of smaller volumes of fluid, is associated with decreased myocardial stunning.[7] Of note, recent studies have demonstrated evidence for cerebral "stunning" as well.[11] Not only does increased frequency of therapy prevent fluid accumulation but the UFR for such sessions is usually in the safe range of < 10 mL/kg/hr. Furthermore, as demonstrated by the Frequent Hemodialysis Network Daily Trial, frequent HD was associated with an average reduction of 9.7 mm Hg in systolic blood pressure despite fewer antihypertensive medications.[6] Taken together, it is highly plausible that more frequent HD may result in decreased mortality.

METABOLIC ISSUES

Metabolic parameters must be considered in the prescription. The dialytic removal of potassium, phosphorus, middle molecules, and the correction of acidosis are greatly affected by specific components of the dialysis prescription. Individualized prescriptions will include frequency, session length, dialysate composition, and UFR as influenced by lifestyle and diet. Tables 2 and 3 display the dialysate compositions available using NxStage bags or PureFlow Saks, respectively. The sodium, calcium, and magnesium concentrations are the same in all solutions, but potassium, chloride, and lactate vary. Typically, lactate is rapidly metabolized by the liver and therefore any increase in lactate level is very transient. In rare patients, rapid exposure to lactate can cause symptoms of lactate intolerance. Slowing the rate of lactate exposure, by decreasing dialysate lactate concentration, DV or dialysate flow rate, allows the liver to adequately metabolize the lactate. The dialytic removal of larger molecules requires time (session length). Phosphorus removal involves intercompartmental transfer, dependent on the concentration gradient and time. Potassium removal is conceptually similar with a much faster transfer rate. Although these vary in clinical importance, they require attention and the various dialysate

Table 2. Composition of NxStage™ (5 L) Dialysate Bags

Constituents	RFP-204	RFP-205	RFP-207	RFP-209	RFP-211
Lactate					
mEq/L	40	35	45	45	40
mmol/L	40	35	45	45	40
Potassium					
mEq/L	1	3	1	2	2
Sodium					
mEq/L	140	140	140	140	140
Calcium					
mEq/L	3	3	3	3	3.5
mmol/L	1.5	1.5	1.5	1.5	1.75
Magnesium					
mEq/L	1	1	1	1	1
mmol/L	0.5	0.5	0.5	0.5	0.5
Chloride					
mEq/L	105	112	100	101	106.5
Glucose					
mg/dL	100	100	100	100	100
Osmolarity (Calculated)					
mOsmol/L	294	298	294	296	296

compositions help. A balance is needed among lifestyle and patient-specific attributes/desires, clinically important metabolic measures, and administrative necessities.

UNIQUE NxStage (LOW-VOLUME DIALYSATE) DIALYSIS CONCEPTS

Conventional HD uses a large volume of dialysate that is poorly saturated (~50%) with urea. From the perspective of water utilization, these treatments are inefficient. They require on-line generation of dialysis fluids, which necessitates a reverse osmosis unit and attendant plumbing changes to the home, or (conceivably) storage in the home of a very large quantity of premade bagged dialysate. Alternatively, one could use a smaller volume of dialysate if one had the ability to do so more efficiently, that is, to achieve a much higher dialysate saturation. We discuss the theory underpinning the high (water) efficiency of the low DV approach to HD and suggest strategies for the initial and subsequent prescription for patients utilizing variations of these modalities. Although short-duration high-frequency HD utilizing this highly efficient low DV approach could be performed using almost any HD platform, its use has been championed by the NxStage System.[9]

The NxStage PureFlow SL™ generates ultrapure dialysate from concentrate as 40, 50, and 60 L batches (Saks) (Table 3), that can be utilized with a 96-h expiry. The prescription discussion describes utilizing multiples of these volumes. This approach is similar to PD in that the scarce commodity is the dialysate. The similarities to PD include 1) low DVs compared with conventional HD; 2) highly saturated effluent dialysate; 3) a specific amount of dialysate is prescribed as opposed to a dialysate flow rate; 4)

Table 3. Composition of NxStage™ PureFlow Saks

Constituents	Sak 301/401	Sak 302/402	Sak 303/403	Sak 304/404	Sak 305/405	Sak 306/406	Sak 307/407
Lactate							
mEq/L	45	40	45	45	45	45	40
mmol/L	45	40	45	45	45	45	40
Potassium							
mEq/L	1	1	1	2	1	2	1
Sodium							
mEq/L	140	140	140	140	140	140	140
Calcium							
mEq/L	3	3	3	3	3	3	3
mmol/L	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Magnesium							
mEq/L	1.0	1.0	1.0	1	1	1	1
mmol/L	0.5 L	0.5 L	0.5	0.5	0.5	0.5	0.5
Chloride							
mEq/L	100	105	100	101	100	101	105
Glucose							
mg/dL	100	100	100	100	100	100	100
Batch Size							
Liters	60	60	50	60	40	50	50

lactate is the source of bicarbonate; and 5) there are limited options for dialysate electrolyte content. Like PD, when using NxStage, larger patients have larger urea distribution volumes. For effective HD with NxStage in these larger patients, and to achieve target Kt/V, larger amounts of dialysate/session will be required, and its saturation may be modulated as discussed further. In PD, because transport status is mostly constant, dialysate saturation is altered by changes in dwell time. In the FLDVA, the prescription will determine the dialysate saturation.

ACHIEVING HIGHLY SATURATED DIALYSATE

Standard thrice-weekly HD is generally performed using a blood flow rate (Qb) of approximately 400 mL/min and a dialysate flow rate (Qd) 1.5 to 2 times Qb (ie, 600-800 mL/minute). At these rates, dialysate saturation is about 50%. In FLVDA, we reverse the flow rate ratio so that Qd << Qb, which leads to higher dialysate saturation. When patients undergo ultrafiltration during the dialysis treatment, the ultrafiltrate (UF) formed, while derived convectively over the course of the session, will equilibrate with the dialysate and will be saturated to the same extent as is the dialysate. The dialysate effluent volume is equal to the prescribed DV plus the UF volume. Therefore, the dialysate effluent flow rate (Qeff) is equal to Q(prescribed DV + UF volume). The NxStage term flow fraction (FF) is the ratio of total effluent fluid flow rate to blood flow rate:

$$FF = Qeff / Qb \qquad \text{Equation 1}$$

Figure 1 depicts the effect of varying FF on the dialysate saturation for urea and creatinine: note that higher dialysate saturation is achieved at lower FF.

In our FLDVA, saturating dialysate is very water efficient. Lowering the FF, which lowers the dialysate flow relative to the blood flow rate, will allow more contact time between blood and dialysate, thereby increasing dialysate saturation. At an FF of about 40%, the urea saturation is about 90%, so any FF lower than that leads to an even higher urea saturation (Fig 1). The session length of a NxStage™ treatment is determined by how long it takes to run a prescribed amount of dialysate through the system. Added to that prescribed DV is the volume of UF per session. The physician prescribes: 1) the volume of dialysate to be utilized each session; 2) dry weight, which determines the amount of UF; 3) the FF; and 4) the Qb, which is usually maximized. Qd is derived from the prescribed FF and effluent DV. The (UF + dialysate) volume divided by Qd determines the session duration. The NxStage™ System One has a maximum Qd of 200 mL/min; the "S" model has a maximum Qd of 300 mL/min. We manipulate these variables to accommodate the patient's lifestyle.

Another way to understand this "upside down" form of HD is this. When Qd is much lower than Qb, dialysate saturation will be very high (Fig 1). Imagine dialysate dripping slowly through the dialyzer while a high Qb presents a huge amount of urea to diffuse across the dialyzer membrane. The dialysate will be 100% saturated with urea. As Qd increases at the same Qb, urea saturation decreases.

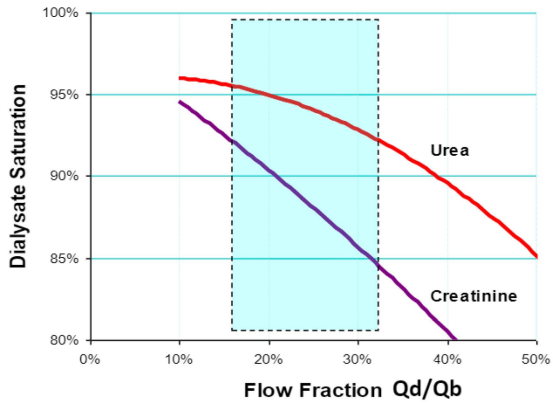

Figure 1. The relationship between flow fraction (Qd/Qb, dialysate flow rate/blood flow rate) and dialysate saturation, adapted by NxStage from the original work of Leypoldt and colleagues.[12] Originally it was thought that optimal FF would be that shown in the blue shaded area, but as time went on the shift has been toward FFs closer to 40%. Abbreviations: FF, flow fraction.

A lower FF will increase dialysate saturation as depicted in Figure 1 and efficiently utilizes scarce dialysate. However, the slower Qd means the treatment time is longer because the treatment time is determined by the volume of dialysate plus the ultrafiltration volume moving through the system at the Qd, defined by the prescribed Qb and FF.

WHAT IS DIFFERENT ABOUT THE NxStage PRESCRIPTION?

When prescribing a conventional HD treatment, we define values for each of the following parameters: Qb, Qd, treatment time, and the volume of fluid to be removed. When utilizing FLDVA using the NxStage™ platform, we do not prescribe Qd or treatment time. Instead, we prescribe a DV per session and an FF. When doing so, treatment time becomes a *dependent* variable that is a function of Qb, FF, and the total effluent volume (dialysate + UF). For example, consider a patient prescribed a DV of 25 L/session with an FF of 40%, Qb 400 mL/min and an average UF of 2L per session. The average treatment time may be calculated in the following manner:

$$FF = Qeff/Qb$$

Rearranging Equation 1

$$Qeff = FF \times Qb$$

Solving for Qeff, we find that

$$Qeff = 0.4 \times 400 = 160 \text{ mL/min}$$

With a total effluent volume of 27,000 mL (25 L dialysate + 2L UF) processed at a rate of 160 mL/min we obtain

$$\text{Time} = 27,000 \text{mL}/160 \text{ mL/min} = 169 \text{ min}$$

Understanding the above, it becomes clear that varying the prescribed treatment parameters will cause the treatment time to vary. Table 4 summarizes the effect of alterations in treatment parameters on the duration of treatment. When estimating the initial prescription (see the following) one should choose treatment conditions that deliver a total weekly dialysis time of at least 12 hours in patients with trivial residual renal function. Our reasoning is that for the removal of larger molecular weight species that equilibrate very slowly, the patient performing FLVDA deserves no less total dialysis time than does the conventional in-center patient. The NxStage machine autocalibrates during treatment and therefore adds a few minutes to the treatment.

THE ROLE OF UREA KINETICS

We are not enamored of the use of Kt/V_{urea} to assess the "adequacy" of dialysis. Nonetheless, it is a useful tool for the quantification of dialysis dose and for the initial approach to the FLDVA dialysis prescription. The nomogram depicted in Figure 2 may be used to determine the dose of dialysis needed as single pool (sp) Kt/V_{urea} to obtain a desired weekly standardized Kt/V_{urea} for various dialysis frequencies.[13] As shown, when doing conventional thrice-weekly HD, one seeks to attain a $spKt/V_{urea}$ of 1.2 to achieve the usually targeted standardized weekly Kt/V_{urea} of 2.0. By following the curves for the various session frequencies, this decreases to a $spKt/V_{urea}$ of approximately 0.55 when dialyzing 5 times weekly.

When thinking of Kt/V_{urea} for NxStage, it is helpful to use an analogy with PD. The weekly Kt/V_{urea} in PD is calculated as follows:

$$Kt/V_{urea} = \frac{[(D/P_{urea})(\text{Dialysate drain volume/day})] \times 7 \text{ days}}{V_D \text{Urea (TBW)}}$$

By analogy, the *per treatment* Kt/V_{urea} using NxStage™ is calculated as

$$Kt/V_{urea} = \frac{[(D/P_{urea})(\text{Dialysate drain volume/treatment})]}{V_D \text{Urea (TBW)}}$$

The D/P_{urea} is the percentage saturation, which is determined by the FF. Note as well that "time" does not enter into the per treatment calculation of Kt/V_{urea}; thus, a fixed FF guarantees saturation and delivered Kt/V_{urea} for prescribed DV independent of time. For example, consider a patient with TBW 45 L who is prescribed a DV per session of 25 L with FF of 40%. As seen in Figure 1, dialysate saturation will be approximately 90%. Thus the Kt/V_{urea} for that treatment will be (25L × 0.9)/45L = 0.5. This will be true whether the treatment time is short (due to a faster Qb) or long (due to a slower Qb).

ESTIMATING THE INITIAL PRESCRIPTION

With this understanding, we can now estimate the initial prescription (DV and FF) for an 80 kg patient using FLVDA. The patient has lost all RKF, prefers to dialyze 5 times weekly, and has a reliable access that can deliver a Qb of 400 mL/min.

Table 4. Effect of Alterations in Treatment Parameters on Duration of Treatment in FLVD Approach

Treatment time increases with
Larger dialysate volume
Greater UF
Lower FF
Slower Qb
Treatment time decreases with:
Smaller dialysate volume
Less UF
Higher FF
Faster Qb

As shown in Figure 2, the required per treatment Kt/V_{urea} is approximately 0.55 ($Kt/V_{urea} = 0.55$). That means that the volume of 100% saturated dialysate per session, Kt, = 0.55 V.

t in this approach = one treatment.

If we approximate V as 0.5 weight in kg (Wt) then Kt = (0.55) (0.5) = .275 Wt.

Kt = (% saturation × DV) = .275 Wt.

If the dialysate saturation is 100%, then the Kt = DV = .275 weight = 22L. Achieving 100% saturation is unrealistic.

If however the FF is 0.4 (realistic), the saturation is 90%, then Kt = 0.9 × DV = .275 weight.

DV = .275/0.9 weight = 0.3 weight.

Thus, an 80 kg person would require a DV of 0.3 × 80 = 24 L at an FF of 0.4.

Then **initial DV = 0.3 weight in kg at a FF of 40**. Round that up to nearest 5L (since bags or sacks of fluid are in multiples of 5L).

The initial, estimated prescription for this 80 kg person would be a DV of 25 L and an FF of 0.4.

What if the measured weekly standardized Kt/V_{urea} is only 1.90 and the patient is symptomatic of underdialysis such that you wish to increase the dialysis dose? Your choices would appear to be to either increase DV/session or increase the saturation of dialysate (by decreasing FF). However, either of these strategies will prolong dialysis session time, which many patients dislike. One solution is to significantly increase DV/session and simultaneously increase FF. If we increase DV to 30 L/session (an increase of 20%) and increase FF to 50% (which will decrease dialysate saturation from 90% to 85%, a decrease of 5.6%), then Kt (the volume of saturated dialysate per treatment) will have increased from 22.5 L (0.9 × 25L) to 25.5 L (0.85 × 30L) an overall increase of 13.3%. Because V (TBW) has not changed, the obtained $spKt/V_{urea}$ will have increased by approximately 13.3% and the standardized weekly Kt/V_{urea} calculated from this will have increased accordingly. The effects on time will (approximately) offset one another (in fact, if we assume average UF of 2L and calculate the time of treatment for each of these settings as outlined previously, it will have decreased from 169 to 160 minutes). Thus, one can leverage the opposing time effects on time of therapy of increasing DV/session and increasing FF to achieve greater overall higher dialysis dose without increasing session length.

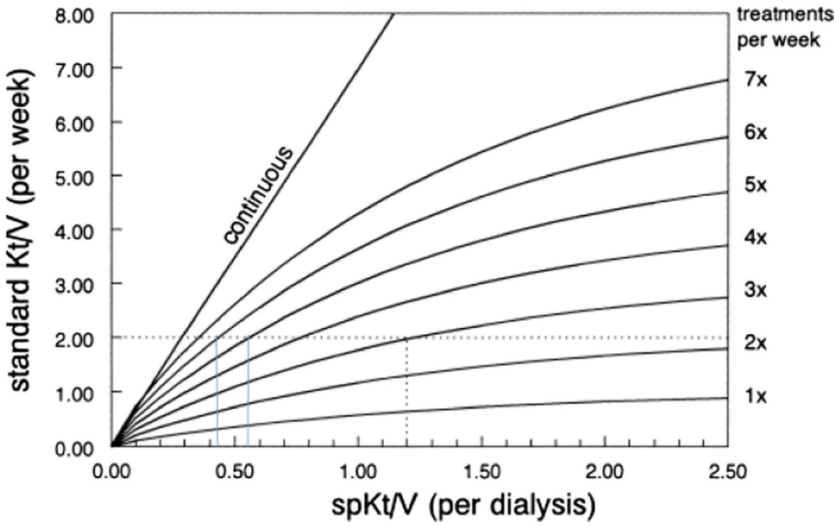

Figure 2. The relationship of single pool Kt/V_{urea} to a weekly standardized Kt/V_{urea}. Gotch was the first to describe how dialysis therapies of differing strategies could be compared with each other relative to urea clearance.[13] The horizontal line at the weekly standardized Kt/V_{urea} intersects the vertical lines at frequencies of 6, 5, and 3 treatment sessions/week. The single pool $Kt.V_{urea}$ for these are 0.43 (rounded up to 0.5), 0.55 (rounded up to 0.6), and 1.2. (Adapted from Gotch,[13] by permission of the European Renal Association–European Dialysis and Transplant Association.)

As mentioned previously, many patients dislike increasing session length. Despite the approach just discussed, it sometimes is the last resort to increase dose as measured by urea reduction ratio (URR) or Kt/V_{urea}. Another circumstance where session length may be increased is when the UF goal is increased. Because the UF volume is added to the dialysate effluent volume, it affects session duration.

Session extension in minutes for UF is

Volume to be UF'ed in mL/session/Qeff Equation 2

The unit of (mL/session)/(mL/min) is min/session. Assume a prescribed FF of 40% and a Qb of 400 mL/min. Then by Equation 1, Qeff is 160 mL/min (0.4 × 160 mL/min). If a liter of UF is to be removed then session duration is increased by 1000 mL/session/160 mL/min or 6.25 minutes. In general, with the FFs and blood flow rates typically used, each liter of ultrafiltration adds 6 to 7 minutes to a treatment session. Sometimes, that awareness acts as an incentive to limit fluid intake and the subsequent need for ultrafiltration. At other times, patients who want to drink more fluid know that later that day it will be removed and because of the frequency of FLDVA treatments, fluid will not accumulate to a harmful excess. This deeper understanding of the subtleties of the therapy and its interconnectedness to behavior will be important to the long-term success of this and any other form of dialysis.

Table 5. Individual FLDVA Dialysis Session Volumes by PureFlow Batch Size

40 L Batch
One session of 40 L
Two sessions of 20 L each
50 L batch
One session of 50 L
Two sessions of 25 L each
60 L batch
One session of 60 L
Two sessions of 30 L
Three session of 20 L

Another aspect of the FLDVA that helps accommodate lifestyle is the frequency of preparing baths of dialysate using the PureFlow. Minimizing how often dialysate is prepared is a strategy involved in the volume/session prescribed and how batches are most efficiently utilized. Table 5 suggests some such strategies.

Finally, in conventional HD, the URR is utilized as a measure of delivered dose. HHD patients also measure a predialysis and postdialysis urea concentration to derive Kt/V_{urea}. In order to compare modalities of different frequencies, weekly standardized Kt/V urea is calculated from the per treatment Kt/V. The relationship between URR and Kt/V_{urea} at the operating conditions of FLVDA is shown in Figure 3.

THE CONTRIBUTION OF RESIDUAL KIDNEY FUNCTION

The process for a patient with RKF is roughly the same. If a patient has a residual Kt/V_{urea} of 1, then we must provide a standardized Kt/V_{urea} of just 1 by dialysis. As depicted in Figure 2, just 3 weekly treatments with $spKt/V_{urea}$ of 0.5 would provide the dialytic goal. Alternatively, one could provide 2 treatments per week, each with $spKt/V_{urea}$ of approximately 0.8. Using the approach

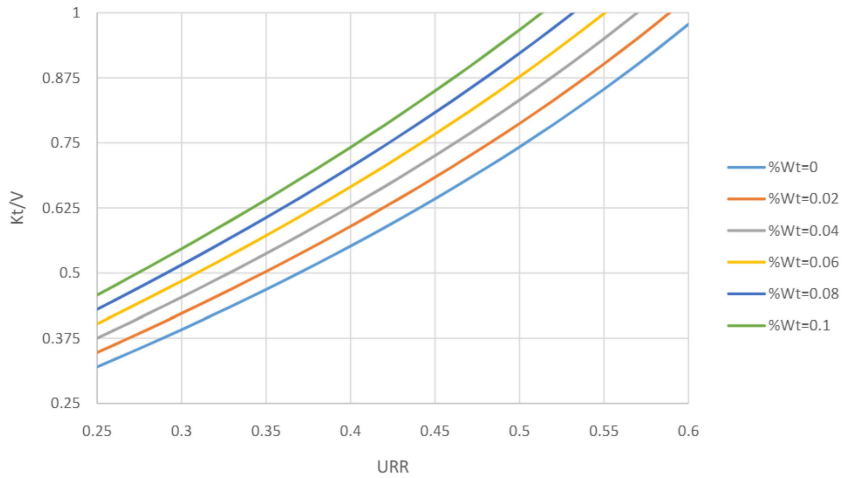

Figure 3. The relationship between Kt/V_{urea} and urea reduction ratio (URR) in the operational range if typical NxStage treatments shown for differing magnitudes of ultrafiltration as % wt removed (courtesy of Ken Leypoldt, PhD). The URR only reflects a drop in urea concentration during a session which urea is removed convectively if there is ultrafiltration and that convective removal contributes to "clearance."

aforementioned, one could then model the prescriptions necessary to achieve these values as we did previously assuming an RKF contribution of zero.

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