ASN DIALYSIS ADVISORY GROUP

ASN DIALYSIS CURRICULUM

Writing the Home Hemodialysis (HHD) Prescription

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Goals For A Successful HHD Prescription

- **SOLUTE REMOVAL**
- **Small solute target: std Kt/V > 2.0**
  - Achieved with lower spKt/V than in-center HD
    - For 5 treatment per week target spKt/V ~ 0.55 - 0.60
    - For 6 treatment per week target spKt/V ~ 0.45
- **Phosphate clearance**
- **Middle Molecule clearance**

- **FLUID REMOVAL**
- **Avoid high ultrafiltration rates**

- **QUALITY OF LIFE**
- **Need to match prescription to patient lifestyle**

Typical Treatment Parameters For HHD

	Traditional Equipment			*NxStage "Low dialysate volume approach"*	
	Conventional HD	*SDHD**	*NHD***	*SDHD*	*NHD*
Treatments/Wk	3	5-6	5-6	5-6	5-6
Treatment Time (Hrs)	4	2	6-8	2.25-3	6-8
Qb (ml/Min)	400	400	200-250	400	200-250
Qd (ml/Min)	600-800	600-800	300	**130-200**	**60-80**

* SDHD = short daily hemodialysis
** NHD = nocturnal hemodialysis

SDHD - Traditional technology

Approach is exactly the same as in-center HD

- **Clearance**
  - Qb 400; Qd 600
  - Typical spKt/V ~ 0.8
- **Time on therapy**
  - 2 hours – adjust to achieve target clearance
- **Potassium**
  - Adjust according to blood test results
- **Bicarbonate**
  - Adjust according to blood test results
- **Calcium**
  - Adjust according to blood test results
- **Heparin**
  - Bolus 1500-3000 units

New Technology

Technology should adapt to patient's needs.

Patient should not have to adapt to technology.

For patients to embrace HHD, machines should be:

- **Easy and simple to use**
- **Small and unobtrusive in the home**
  - **Minimize storage space requirement**
- **Reliable**
- **Relatively maintenance free**
- **Portable**
- **Affordable**

NxStage machine is the only "new technology" currently available in the U.S. and majority of home HD patients utilize this machine. It has become synonymous with SDHD.
*However to avoid any possible perception of bias, will refer to **NxStage** as the **"Low dialysate volume approach (LDVA)"***

Comparing PD, LDVA and CHD:

Modality	PD	LDVA	CHD
Dialysate Volume (L)	8-18	15-35	140
Dialysate Urea Saturation	High (60-100%)	High (85-90%)	Low (~30-40%)
To change saturation	Change DT	Change FF	n/a
Prescription variables that increase Kt/V:			
-Change dialysate volume	‘	‘	n/a
-Change dialysis saturation	‘ DT	“ FF	n/a
-Change Qb and Qd	n/a	n/a	‘ one or both
-Dialyzer	n/a	n/a	‘ KoA

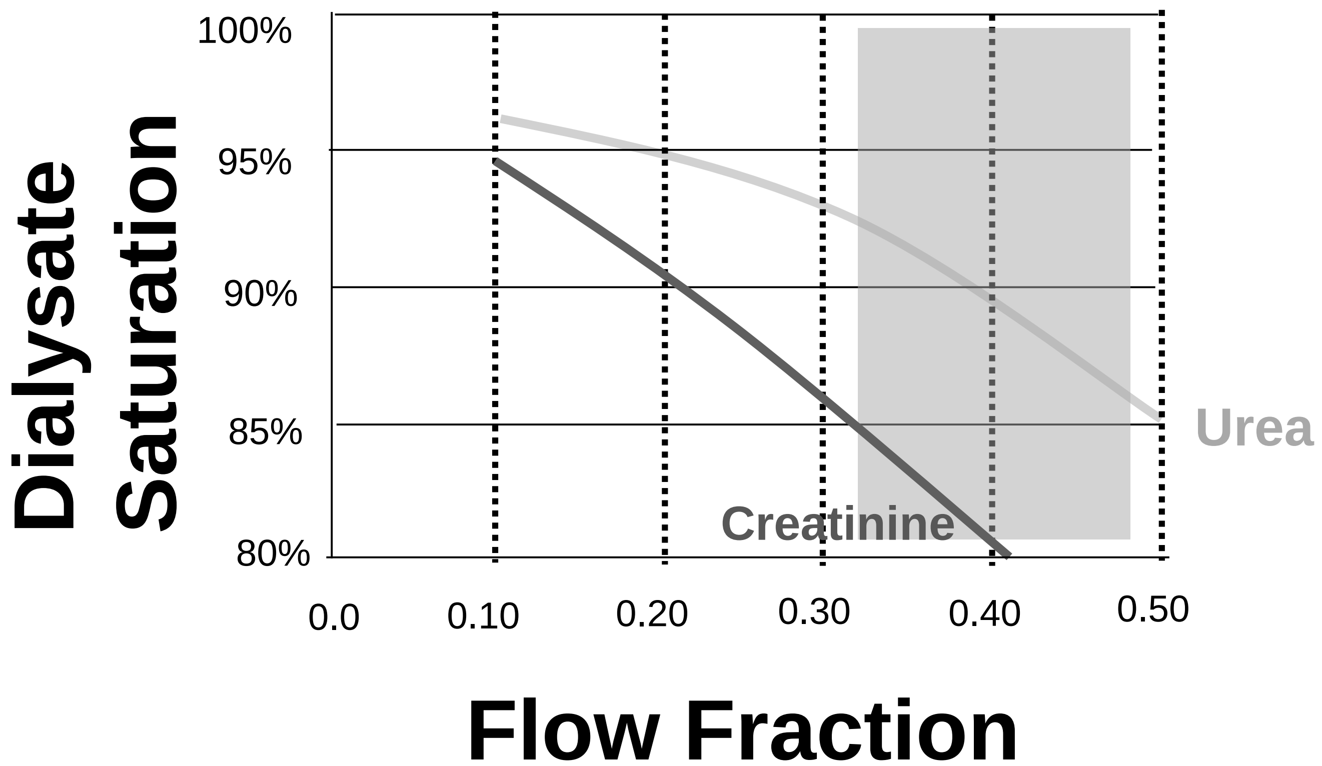
CHD = Conventional HD
DT = Dwell time
FF = Flow Fraction = Qd/Qb

Qd = Dialysate flow rate
Qb = Blood flow rate
KoA = Mass transfer area coefficient

FF and dialysate saturation:

- The LDVA is based on the principle that dialysate fluid is nearly completely saturated with urea if the dialysate flow rate is much slower than the blood flow rate. Consider an extreme example of dialysate trickling through a dialyzer and a huge amount of blood flows across the other side of dialyzer membrane. The huge amount of urea diffusing across the dialyzer will completely saturate the trickling dialysate. As dialysate flow increases relative to blood flow saturation will decrease (though urea clearance increases).
- LDVA results in very efficient use of dialysate.
- The term Flow Fraction (FF) defines the relationship between dialysate flow (Qd) and blood flow (Qb) and is equal to Qd/Qb.
- At low flow fraction Qd relative to Qb is low and dialysate saturation is high.
- At high flow fraction Qd relative to Qb is high and dialysate saturation is lower.

Improving Efficiency by Decreasing Flow Fraction: Q_d/Q_b



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LDVA Prescription, FF, and Treatment Time

- Order appropriate amount of dialysate volume.
- Order flow fraction (which determines dialysate saturation). It is programmed into machine.
- Order Qb. This is not programmed but entered by patient.
- Qd is NOT ordered but is determined by the machine according to the formula Qd = (FF)(Qb) or FF = Qd/Qb.
- Time of therapy is NOT ordered. Time of therapy is a dependent variable. It is dependent on the amount of dialysate prescribed and the Qd that is determined by the machine. The Qd is determined by the flow fraction and the prevailing Qb: Qd = (FF)(Qb).
- The maximum flow fraction is fixed by your order and therefore a minimum saturation is fixed. This guarantees the dialysate fluid will achieve target saturation.
- Achieving target saturation guarantees target spKt/V is achieved at end of treatment.

Prescription, FF, and Treatment Time

- FF = Qd/Qb
- Qd = (FF)(Qb)

- Since FF is fixed by your order, at a constant Qb, Qd is constant. If we prescribe more dialysate volume then time of therapy will INCREASE.

- Since FF is fixed by your order, if there is a decrease in Qb then Qd will decrease and time of therapy will INCREASE.

Exercise: Estimate an initial LDVA prescription

- **Patient**
  - 90 Kg male
  - 5 days per week therapy, SDHD
  - Approximate volume distribution of urea = 45 L

- **Solution:**
  - Target std Kt/V = 2.0; target per treatment spKt/V = 0.6 (slide 3)
  - Then target Kt = (Kt/V)(V) = (0.6)(45) = 27 L. This means that we need 27 L of 100% saturated dialysate fluid to achieve a target Kt/V of 0.6.
  - If we choose to use 30L of dialysate then then the fluid needs to be about 90% saturated to be equivalent to 27 L of 100% saturated fluid
    - (0.9)(30 L) = 27 L
    - FF 0.4 will yield saturation of about 90% (slide 9)

- **Our prescription will be 30L dialysate at FF 0.4. If Qb is 400 ml/min then Qd will be 160 ml/min and time on therapy will be about 188 minutes (30,000 mL / 160 ml/min).**

NxStage LDVA Prescriptions

- Actually, is much easier than that. For SDHD: Pick a reasonable dialysate volume according to patient weight and a reasonable flow fraction. Then measure spKt/V (URR) and calculate std Kt/V. If you do not achieve target std Kt/V change flow fraction or dialysate volume or both and measure spKt/V and calculate std Kt/V again.

- Example of reasonable initial prescriptions for 5 day per week therapy:

Dialysate volume

Small: (<70 kg)	20 liters
Medium: (70-85 kg)	25 liters
Large: (85-100 kg)	30 liters
>100 kg	35 liters

Flow fraction

About 0.40 (40%)

Examine variables that determine Kt/V

Peritoneal Dialysis

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

Modifiable parameters

NxStage =
(per tx Kt/V_{urea})

$$\frac{(\mathbf{D/P_{urea}})(\text{Dialysate drain volume})}{V_D\text{Urea (TBW)}}$$

Fixed

D/P_{urea} is percent saturation and is determined by flow fraction

Adjust prescription when Kt/V is below target:

Modifiable parameters

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

Fixed

- **D/P_{urea}** is percent saturation and is determined by flow fraction
- **Increase saturation**
  - To change percent saturation change flow fraction
  - Lower flow fraction (slower dialysate flow) results in higher dialysate saturation.

OR

- **Increase dialysate volume**

Manipulate variables to achieve target Kt/V

$$\text{Per Treatment Kt/V}_{urea} = \frac{(\mathbf{D/P_{urea}})(\text{Dialysate drain volume})}{V_D\text{Urea (TBW)}}$$

D/P_{urea} is percent saturation and is determined by flow fraction

To increase Kt/V we can:

1) Increase percent saturation (decrease FF)

2) Increase dialysate volume

BOTH strategies will increase time on dialysis

BUT if we generously increase dialysate volume, we could increase FF (increase Qd and decrease percent saturation) and still achieve target Kt/V without increase in time per treatment.

Nocturnal Hemodialysis: LDVA

- Target spKt/V is determined the same way as SDHD

- Approach to FF is different because we want to tailor treatment time to patients sleep time

- For example: 85 Kg patient
- Patients sleeps for 8 hours (480 minutes)
- Patient needs 30 liters of dialysate fluid (slide 13)
- Dialysate flow rate should be about 30,000 ml/480 minutes = 63 ml/min
- If Qb is 250 mL/min then FF = 63/250 = 0.25.
- At FF 0.25 dialysate will be HIGHLY saturated.
- This calculation does not take into account machine re-calibration time which occurs repeatedly during therapy and adds time to therapy.

Dialysate Options

- **Traditional dialysis equipment**
  - Same options as in-center HD

- **NxStage (LDVA)**
  - Limited dialysate options (similar to PD!)
    - 5 liter sterile bags
    - Batch (ultrapure) dialysate production by PureFlow system

NxStage Fluids

	Sterile Bags		PureFlow	
	Higher Buffer	*Lower Buffer*	*High Buffer*	*Lower Buffer*
Lactate	45	40	45	40
Na^+ (meq/L)	140	140	140	140
K^+ (meg/L)	1 or 2	1	1 or 2	1
Ca^{2+} (meq/L)	3	3	3	3
Mg^{2+} (meq/L)	1	1	1	1
Cl^- (meq/L)	100	105	100	105
Dextrose (mg/dL)	100	100	100	100

5 Liter bags

40, 50 or 60 liter sacks

Fluid Removal

- **The approach to fluid removal is exactly the same as in-center conventional HD**

- **Ultrafiltration rates should be low to avoid myocardial stunning and intradialytic hypotension.**

- **Though there is no literature regarding safe UF rates in SDHD it is reasonable to extrapolate from CHD and limit UF to 10-13 ml/kg/hr.**

- **However, intradialytic hypotension at home is UNACCEPTABLE and patients must be educated on methods to avoid excessive UF as well as proper monitoring and interventions for intradialytic hypotension.**

Anticoagulation

- The NxStage machine does not have an internal heparin pump.
- For SDHD treatment time is short enough to use bolus heparin (approximately 1000-2000 units at initiation of treatment).
- For extended treatment time maintenance heparin requires an additional external heparin pump. Heparin dose is typically 1000-2000 units initial bolus followed by 500-1500 units per hour maintenance dosing.

New Technologies In The Future

- **There are at least 2 new HHD machines currently in clinical trial**
  - The machines were developed specifically for HHD
  - Each machine has different technology to simplify home hemodialysis
  - One machine utilizes "sorbent" technology that regenerates dialysate from just 6 liters of tap water
  - Nephrologists will need to learn about prescriptions for new machines as they become available.