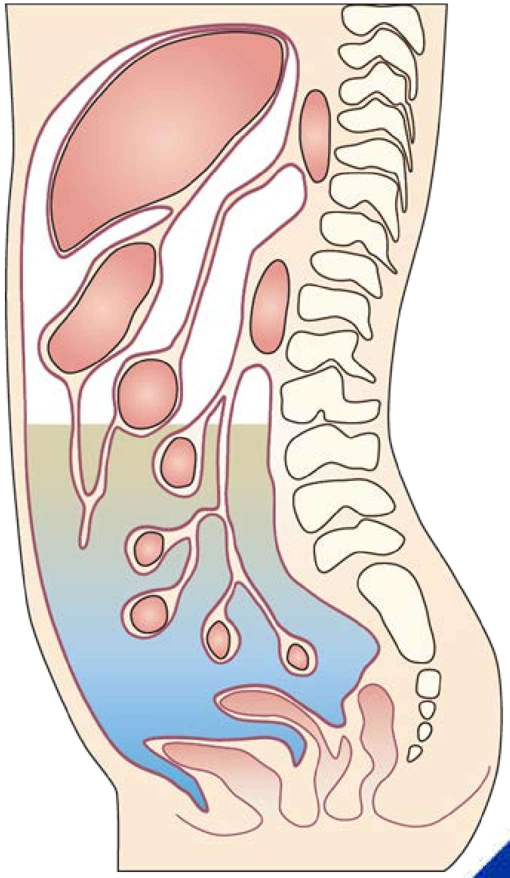
# The PD Prescription



Ryan Blas BSN, RN

Clinical Cons. - Central Division

FRESENIUS MEDICAL CARE

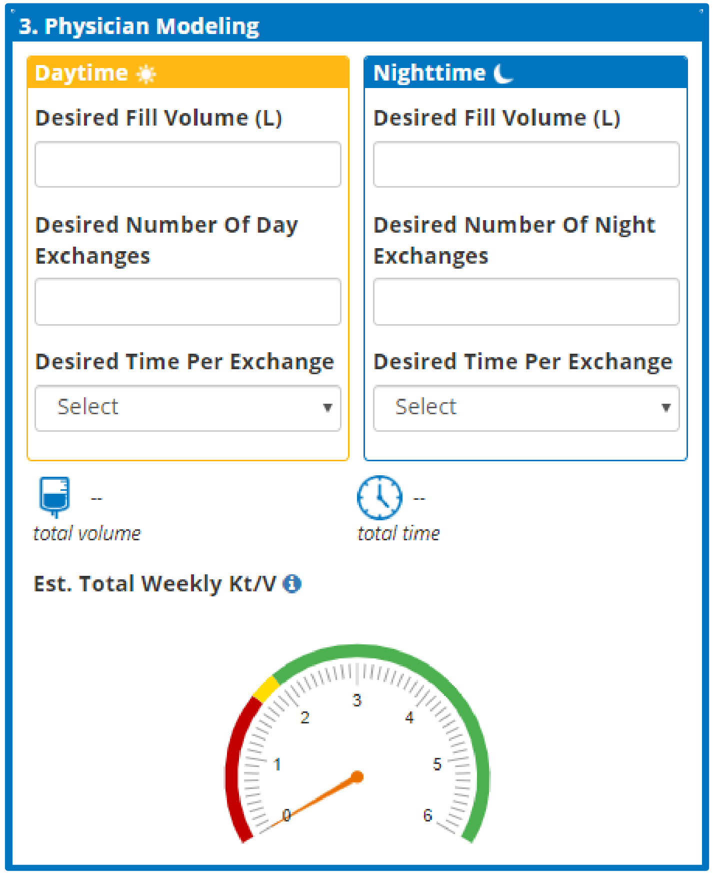
# Disclaimer

- This presentation has been developed by Fresenius Medical Care North America.
- It is intended to provide pertinent data to assist healthcare professionals in forming their own conclusions and making decisions.
- It is not intended to replace the judgement or experience of the attending physician or other medical professionals.
- The treatment prescription is the sole responsibility of the attending physician.

# Disclosure

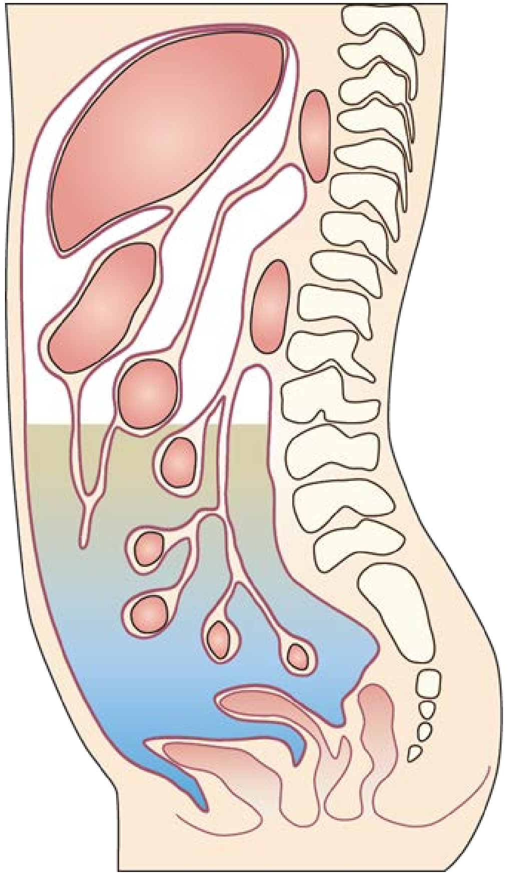
## I have nothing to disclose

# PD Calculator Intended Use




- This course uses a PD Calculator as an example how modeling can facilitate finding individualized PD prescriptions.
- The online PD Calculator is intended for use by clinicians for modeling the dialysis dose (Kt/V) for different peritoneal dialysis prescriptions options. Modeling a PD dose is based on generalized formulas and assumptions derived from patient populations. The output of a modeled prescription is limited in its accuracy and cannot account for the variability seen in individual patients. It is essential that the physician adjusts the prescription according to the individual patient's clinical parameters to ensure the adequacy of the PD prescription.
- The calculator is not intended to replace the judgment or experience of the attending physician. The peritoneal dialysis treatment prescription is the sole responsibility of the attending physician.
- The PD Calculator is not intended to be used for pediatric patients or amputees.

# Course Objectives



- ✓ Discuss adequacy of peritoneal dialysis
- ✓ Create an initial PD prescription using the PD Calculator
- ✓ Describe when and how to adjust and intensify the PD prescription
- ✓ Review sodium sieving and sodium removal in PD

# Adequate Peritoneal Dialysis


Small solute clearance targets are met

Fluid balance, BP control, cardiac markers acceptable

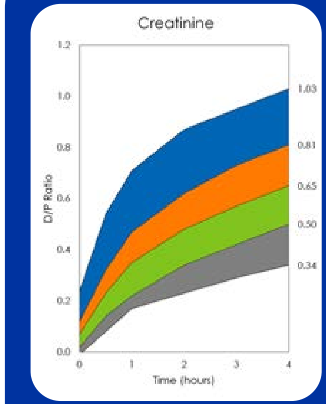

Biochemical markers within acceptable ranges

Maximized quality of life

Perl J, et al. *Clin J Am Soc Nephrol*. 2017;12(5):839-847

# Factors That Affect Peritoneal Clearance

## Transport Type




- Patient-specific
- Should be considered when determining appropriate dwell times for clearance and UF

## Dialysate Volume

- More volume results in more clearance
- Can be adjusted by increasing # of exchanges or dwell volume

## Dwell Time

- Should be based on transport type and clinical needs
- Avoid inappropriately short or long dwells
- Can be affected by catheter complications

## Ultrafiltration Volume

- Difficult to predict accurately
- Individualizing dwell times for maximal UF is critical
- Adjust dextrose strength, consider icodextrin

K/DOQI. *Am J Kidney Dis*. 2006;48 Suppl 1:S91-S97

# Initial PD Prescriptions are Often Generic

… but your patients are not!!

Individualizing prescriptions is easy and a key to success in PD

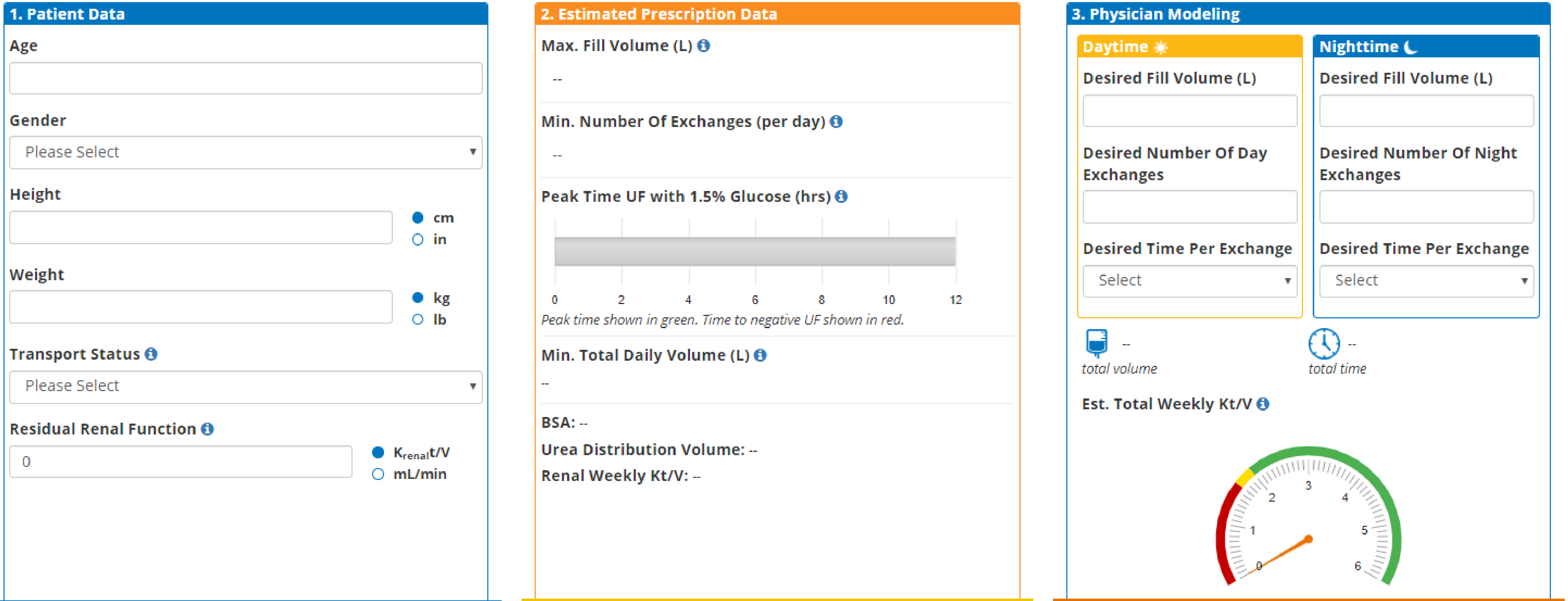
# Individualizing the PD Prescription

## Case Study: New PD Patient

- Mr. R is an 82-year-old retired male new to dialysis
- Has some residual renal function with a GFR 6 mL/min*
- Height: 183 cm, Weight: 88 kg
- Transport type unknown
- Wants to start with manual PD

* For a patient of this size, a GFR ~6 mL/min equals a renal Kt/V ~ 1.34

# Online PD Calculator




## 1. Enter basic patient data

- Age, gender, height, weight
- Transport status
- RRF

## 2. Review estimated data

- Provides general guidance
- Based on modeling assumptions: max fill volume used, 4-hour dwells, continuous therapy, 1 L UF

## 3. Predict outcomes

- Enter parameters and review modeling results for possible prescription options

https://fresenius.pdcalculator.com/

# 4 Steps to Determine the PD Prescription

1. Enter patient-specific characteristics
2. Determine appropriate dwell volume
3. Consider clinical needs for approximating dwell times
4. Model # of exchanges and total volume required for adequate clearance

# Determining the Initial Prescription

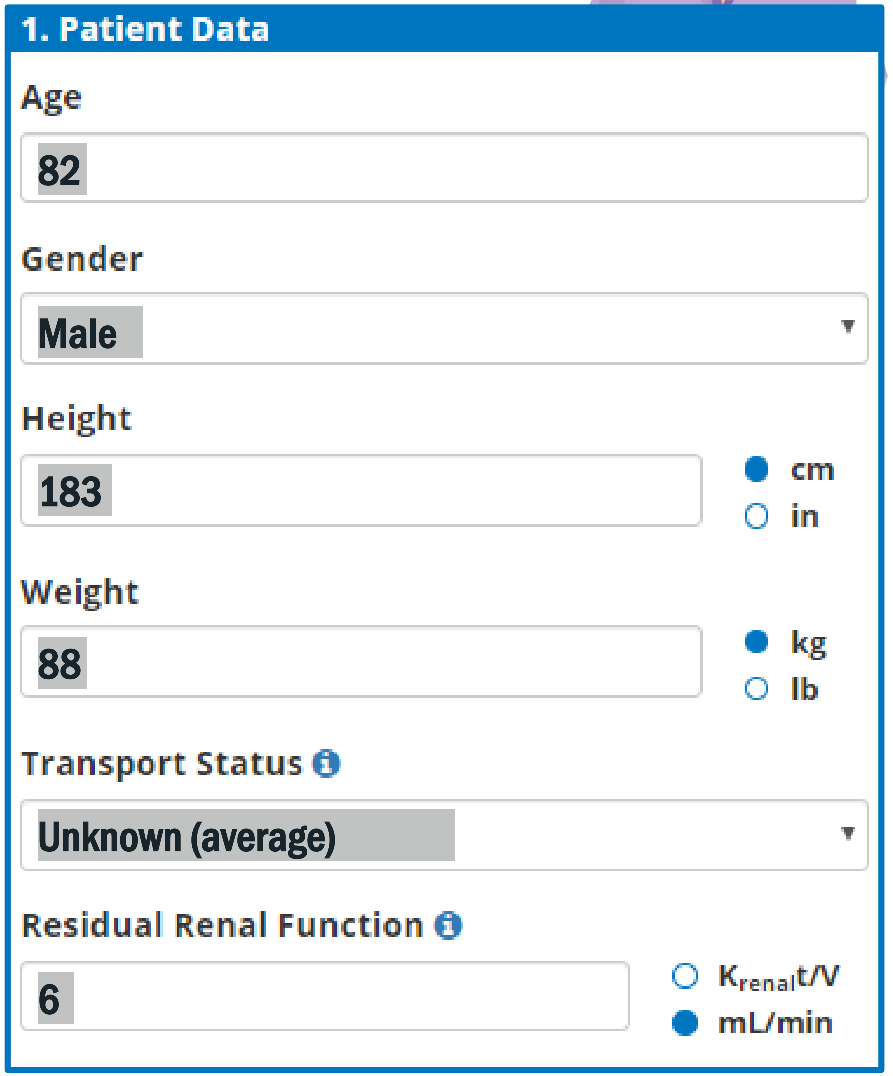
1 Patient Specifics

2

3

4

- Mr. R is an **82-year-old** retired **male** new to dialysis
- Height: **183 cm**, Weight: **88 kg**
- Transport type **unknown – assume average**
- Has decent residual renal function with a **GFR 6 mL/min**



# Determining the Initial Prescription

1 Patient Specifics

2 Dwell Volume

3

4

## Dwell Volume

- Estimations for maximum:
  - Based on patient size
  - Includes UF
- Rule of Thumb:
  - 1.5 L/$m^2$ of BSA
  - Maximum of 3 L
- Initial volume for Mr. R: 1.5 – 2.0 L

**2. Estimated Prescription Data**

**Max. Fill Volume (L)**

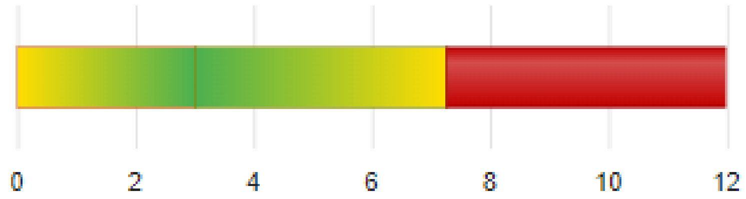
3 L

** Initial volume is often chosen significantly lower and then increased over time*

**Min. Number Of Exchanges (per day)**

2

**Peak Time UF with 1.5% Glucose (hrs)**




*Peak time shown in green. Time to negative UF shown in red.*

**Min. Total Daily Volume (L)**

5.8

BSA: 2.1 $m^2$

Urea Distribution Volume: 45 L

Renal Weekly Kt/V: 1.34

# Determining the Initial Prescription

1 Patient Specifics

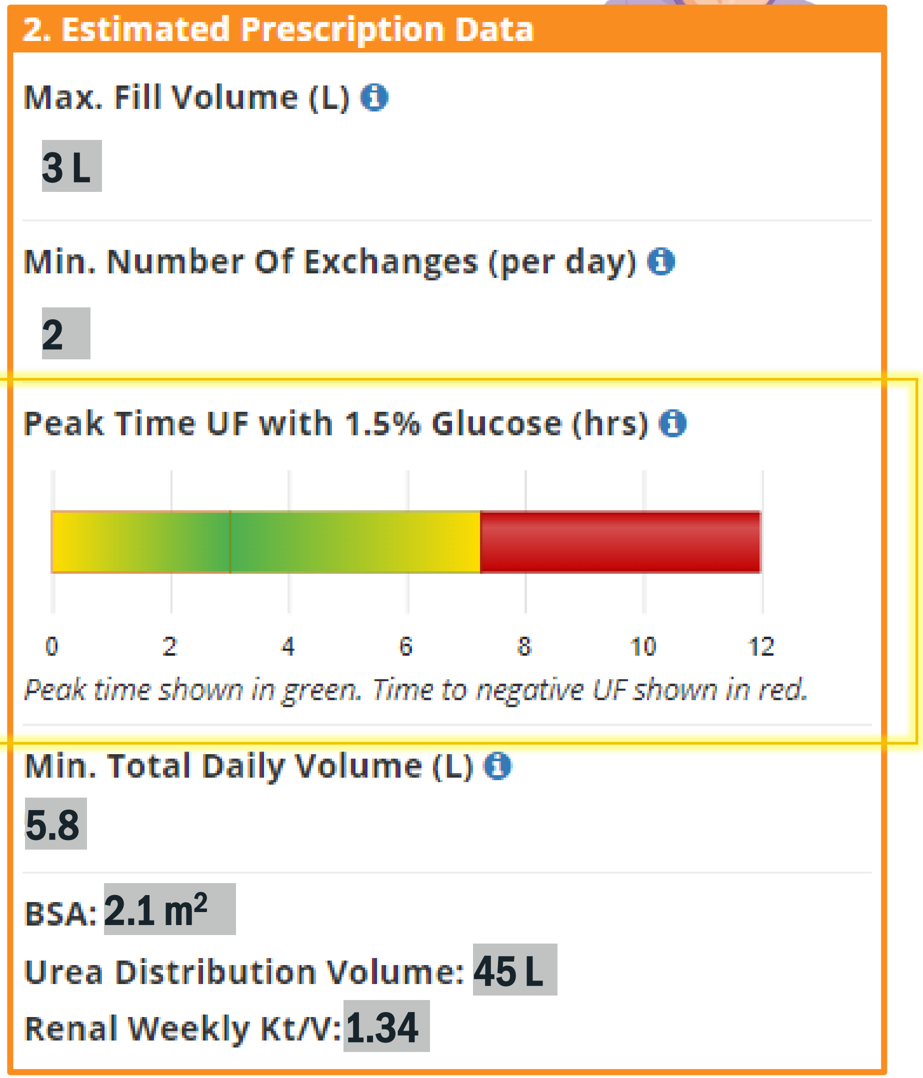
2 Dwell Volume

3 Dwell Time

4

## Dwell Time

- Peak time for UF:
  - Depends on transport type and PD solution used
- Appropriate time for Kt/V:
  - Correlates with peak time for UF
- Avoid:
  - Overly long dwells that result in reabsorption
  - Inefficient short cycles that result in inadequate UF, Kt/V, and sodium removal



# Determining the Initial Prescription

1 Patient Specifics

2 Dwell Volume

3 Dwell Time

4

For many new PD patients with good RRF:

- Achieving adequate clearance is not difficult

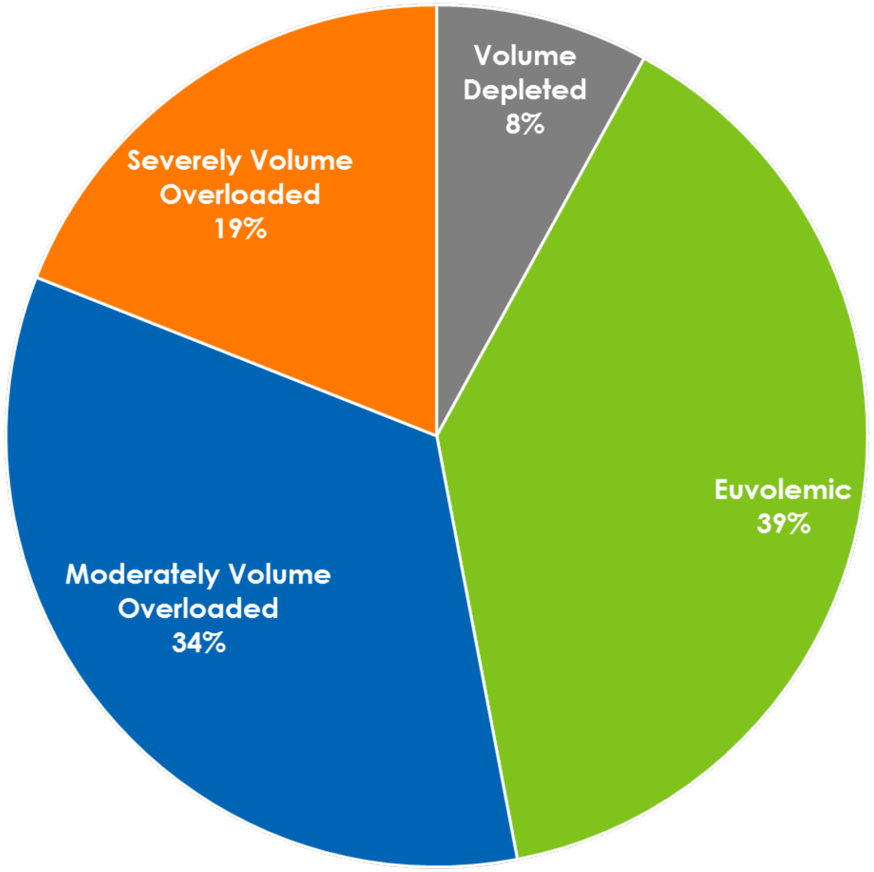
**BUT**

- Many initiate PD fluid overloaded

Consider a patient's UF requirements from the beginning

**Fluid Status of Incident PD Patients**

n = 1054




Van Biesen W, et al. *Clin J Am Soc Nephrol*. 2019;14(6):882-893

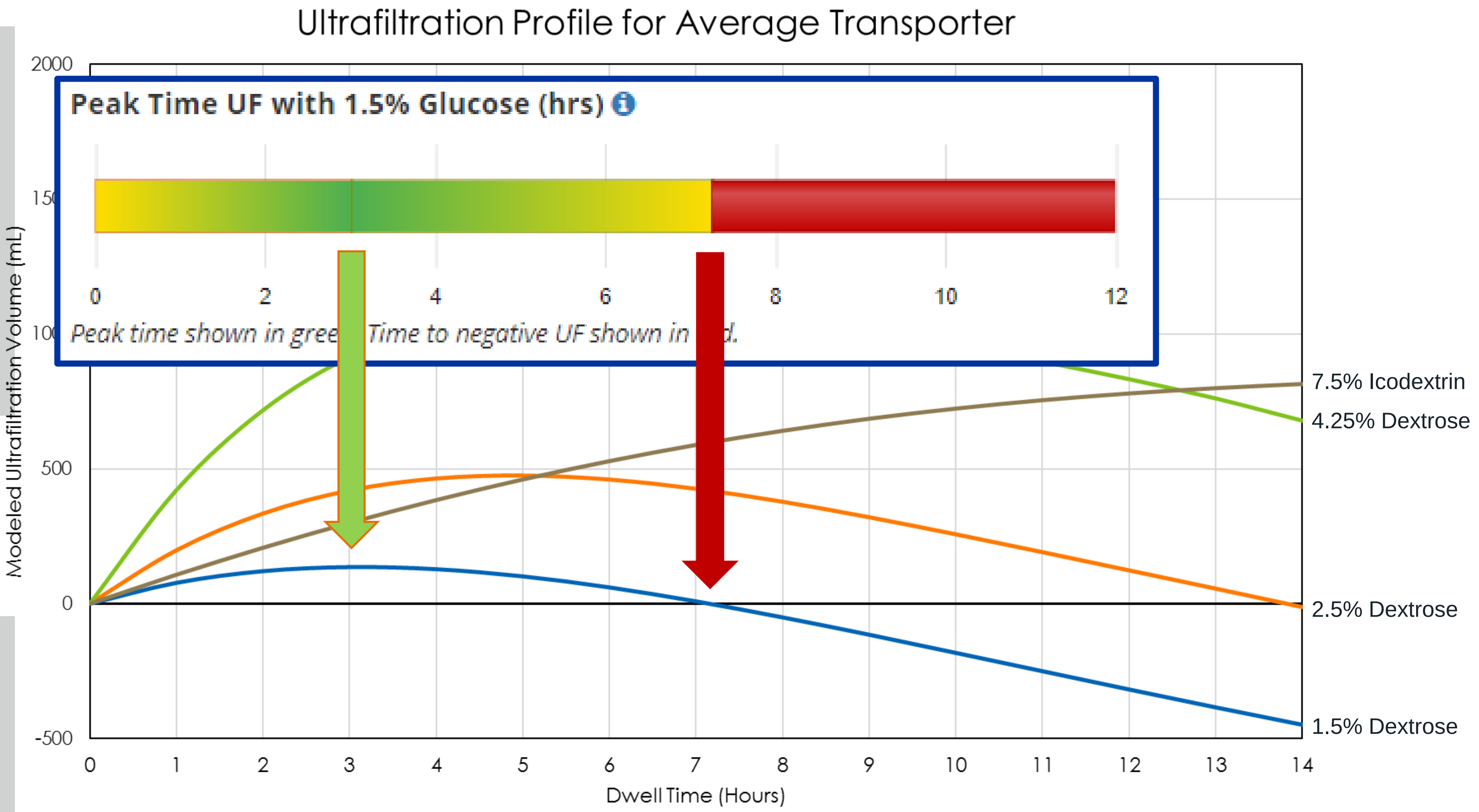
# Dwell Time – Optimizing Ultrafiltration

1 Patient Specifics

2 Dwell Volume

3 Dwell Time

4




- Mujais S, Vonesh E. *Kidney Int Suppl*. 2002;(81):S17-S22

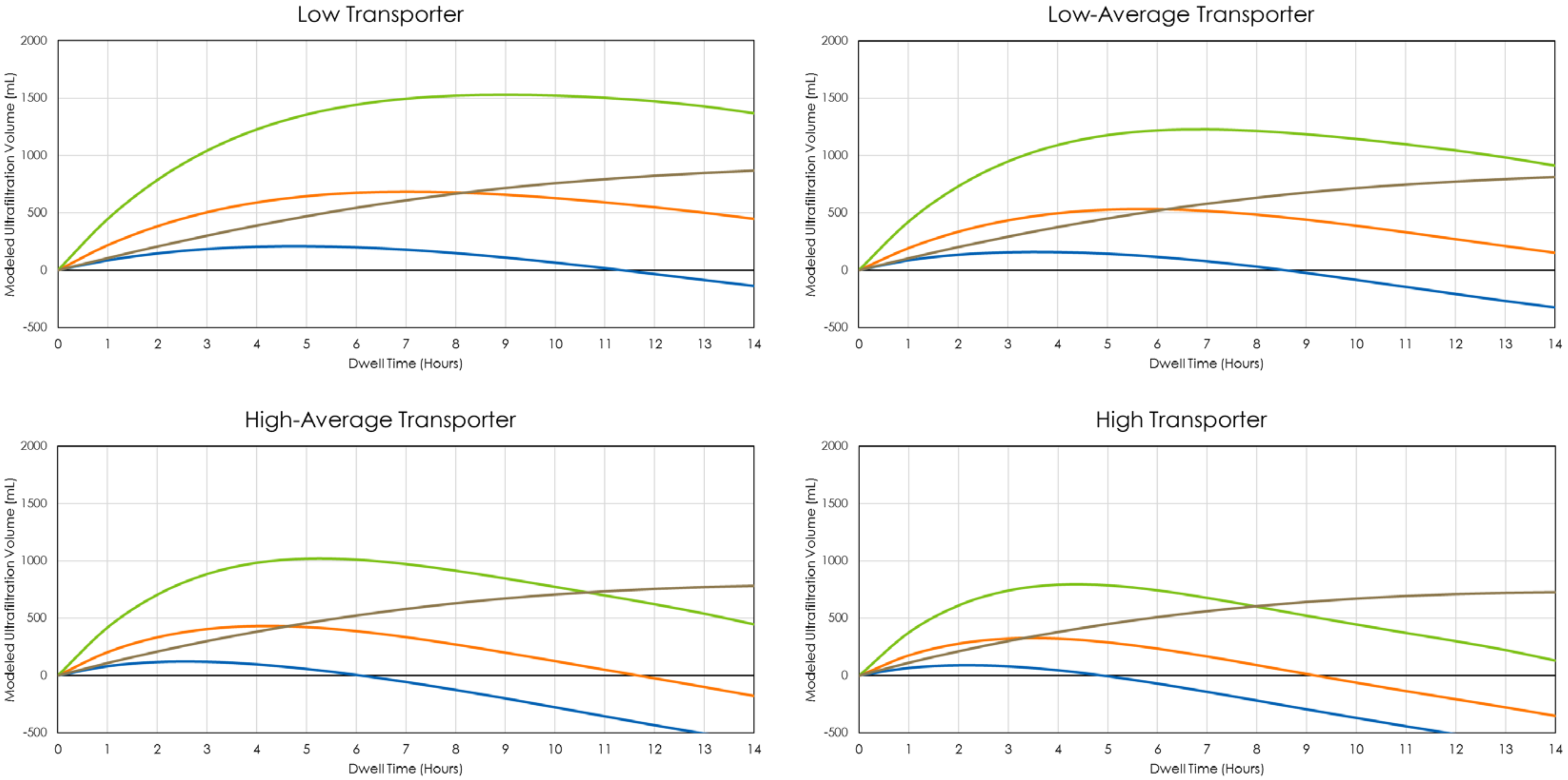
# Resource: Ultrafiltration Profiles

1.5% Dextrose

2.5% Dextrose

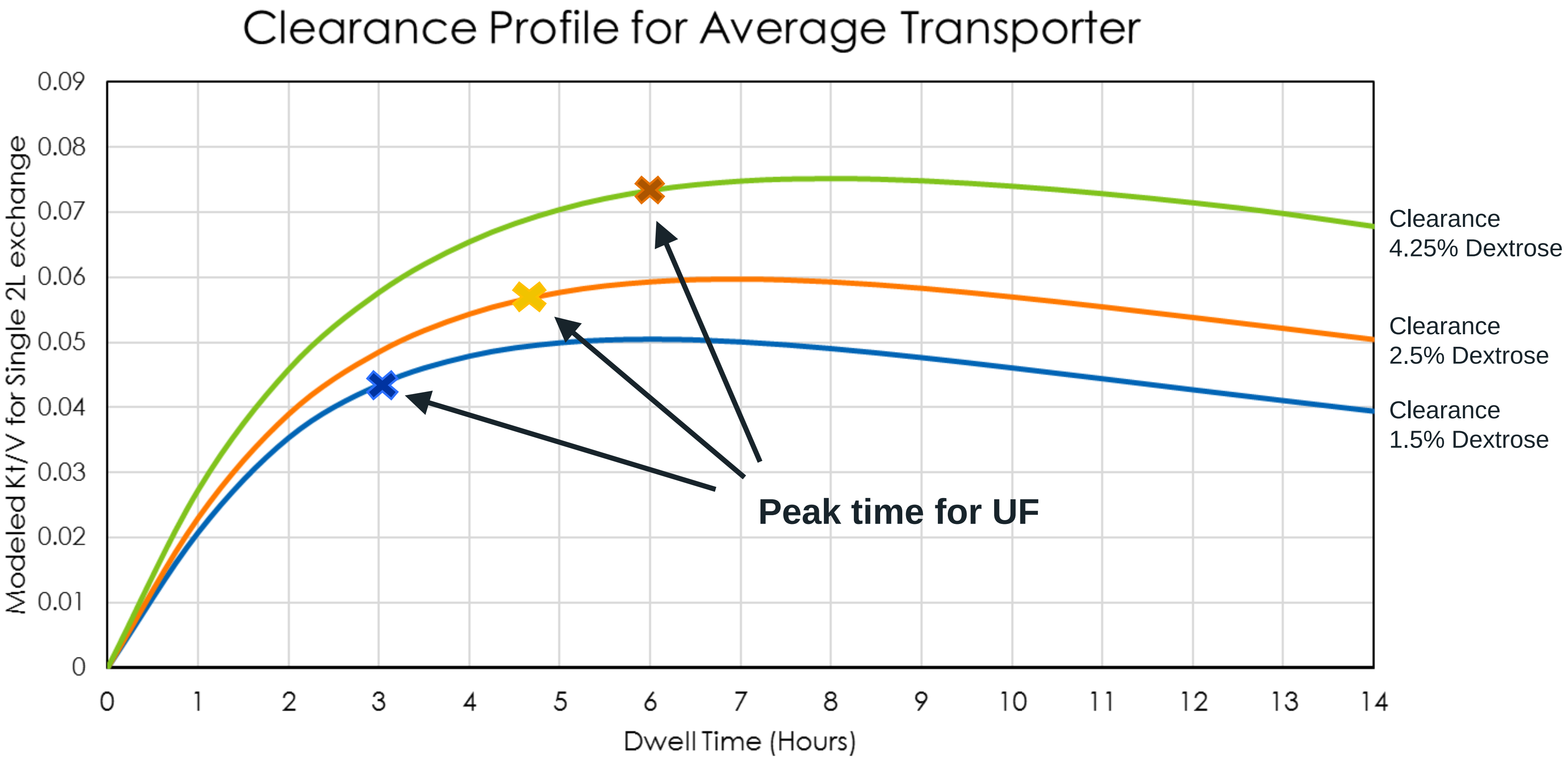
4.25% Dextrose

7.5% Icodextrin




- Mujais S, Vonesh E. *Kidney Int Suppl*. 2002;(81):S17-S22

# Dwell Time – Optimizing Clearance


Choosing a time around the peak time for UF seems a good approximation to ensure effective ultrafiltration and clearance

- Akonur A, et al. *Perit Dial Int*. 2013;33(6):646-654

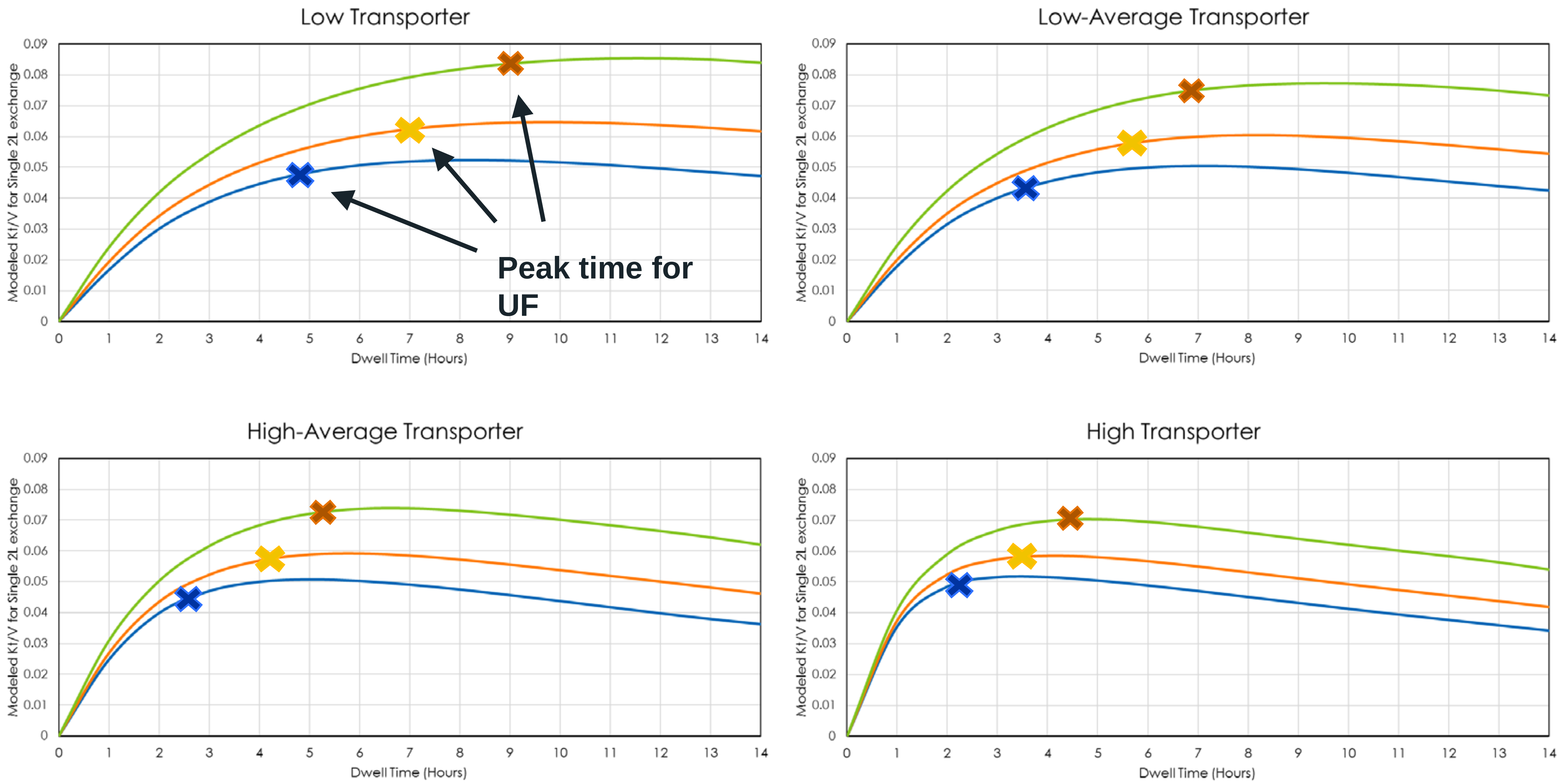
# Resource: Clearance Profiles

1.5% Dextrose

2.5% Dextrose

4.25% Dextrose

7.5% Icodextrin




- Akonur A, et al. *Perit Dial Int*. 2013;33(6):646-654

# Determining the Initial Dwell Time

1 Patient Specifics

2 Dwell Volume

3 Dwell Time

4

## Dwell Time

- Mr R:
  - Good residual renal function
- Considerations:
  - UF peaks at 3 hours with1.5% glc
  - Dwell times of 2 to 5 hr seem feasible
  - Only needs a few exchanges
- Options:
  - Starting with a few 3 h manual exchanges with dry overnight
  - CAPD only possible with >1.5% glc

**2. Estimated Prescription Data**

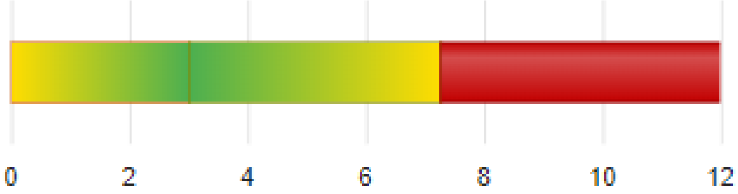
Max. Fill Volume (L)

3 L

Min. Number Of Exchanges (per day)

2

Peak Time UF with 1.5% Glucose (hrs)




*Peak time shown in green. Time to negative UF shown in red.*

Min. Total Daily Volume (L)

5.8

BSA: 2.1 $m^2$

Urea Distribution Volume: 45 L

Renal Weekly Kt/V: 1.34

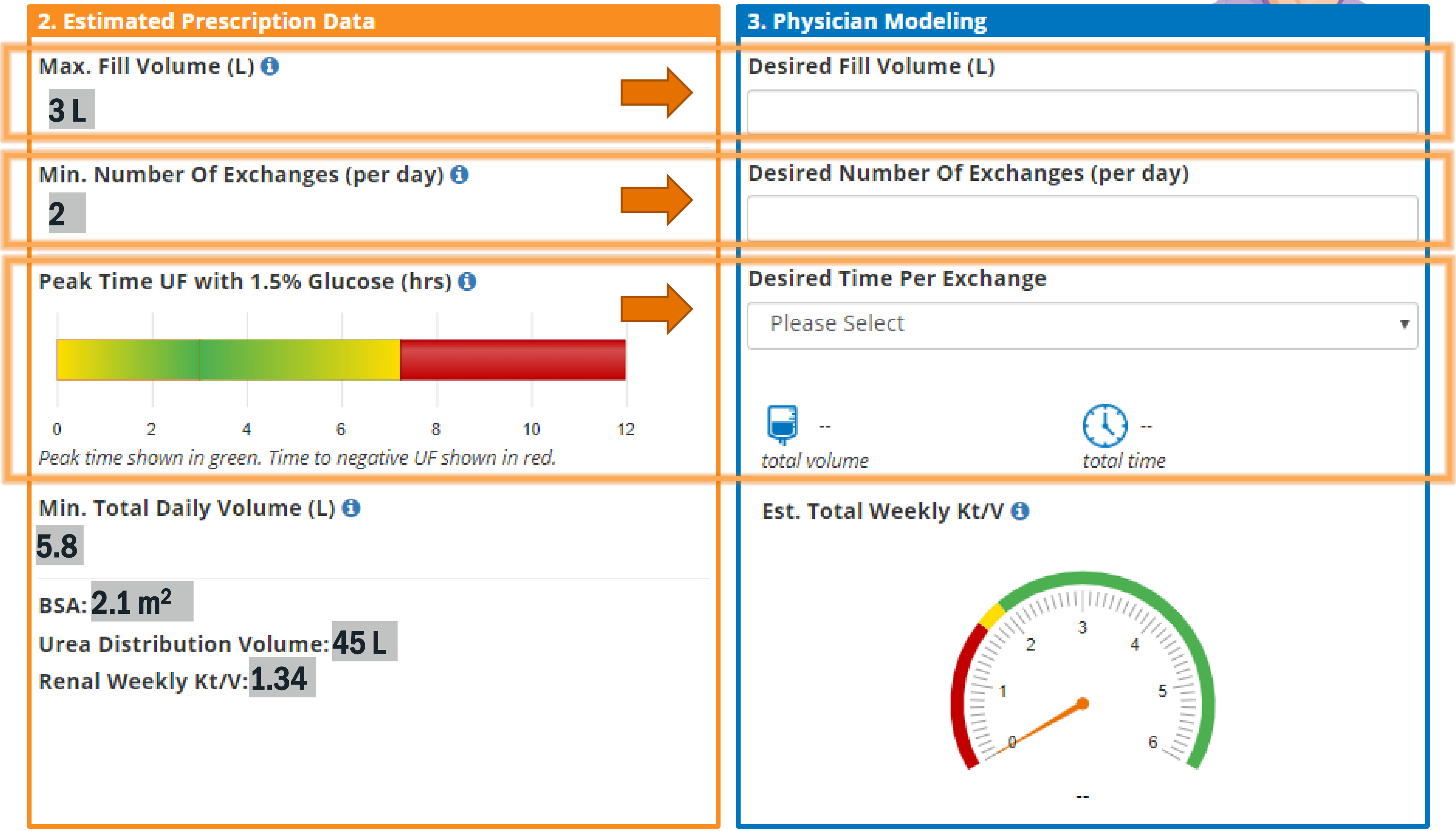
# Determining the Initial Prescription

1 Patient Specifics

2 Dwell Volume

3 Dwell Time

4 Model Options



# Determining the Initial Prescription

1 Patient Specifics

2 Dwell Volume

3 Dwell Time

4 Model Options

**3. Physician Modeling**

Desired Fill Volume (L)

Desired Number Of Exchanges (per day)

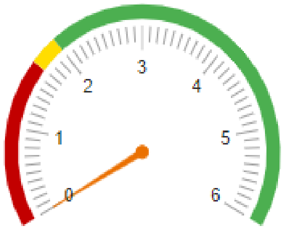
Desired Time Per Exchange

Please Select

-- total volume

-- total time

Est. Total Weekly Kt/V




Modality Input

- ● Simple
- ○ Day/Night

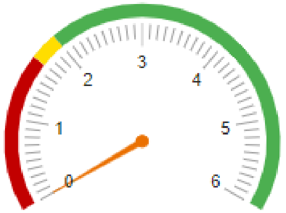
**3. Physician Modeling**

| Daytime | Nighttime |
| --- | --- |
| Desired Fill Volume (L) | Desired Fill Volume (L) |
| Desired Number Of Day Exchanges | Desired Number Of Night Exchanges |
| Desired Time Per Exchange | Desired Time Per Exchange |
| Select | Select |

-- total volume

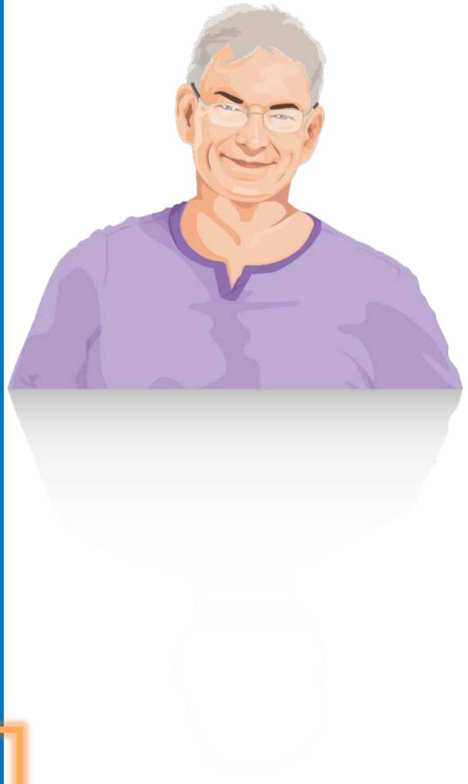
-- total time

Est. Total Weekly Kt/V




Modality Input

- ○ Simple
- ● Day/Night



# Example Initial Prescriptions

1 Patient Specifics

2 Dwell Volume

3 Dwell Time

4 Model Options

## 2. Estimated Prescription Data

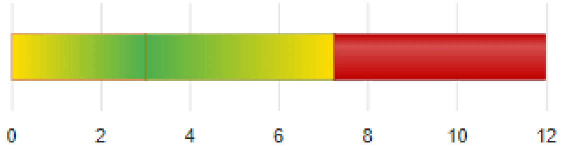
Max. Fill Volume (L)

3 L

Min. Number Of Exchanges (per day)

2

Peak Time UF with 1.5% Glucose (hrs)




*Peak time shown in green. Time to negative UF shown in red.*

Min. Total Daily Volume (L)

5.8

BSA: 2.1 $m^2$

Urea Distribution Volume: 45 L

Renal Weekly Kt/V: 1.34

## 3. Physician Modeling

| Daytime | Nighttime |
|---|---|
| Desired Fill Volume (L): | Desired Fill Volume (L): 2 |
| Desired Number Of Day Exchanges: | Desired Number Of Night Exchanges: 3 |
| Desired Time Per Exchange: Select | Desired Time Per Exchange: 3 hours |

6 L total volume

9 hours total time

Est. Total Weekly Kt/V


## 3. Physician Modeling

| Daytime | Nighttime |
|---|---|
| Desired Fill Volume (L): 1.5 | Desired Fill Volume (L): |
| Desired Number Of Day Exchanges: 3 | Desired Number Of Night Exchanges: |
| Desired Time Per Exchange: 5 hours | Desired Time Per Exchange: Select |

4.5 L total volume

15 hours total time

Est. Total Weekly Kt/V

# Example Initial Prescriptions

- **1** Patient Specifics
- **2** Dwell Volume
- **3** Dwell Time
- **4** Model Options

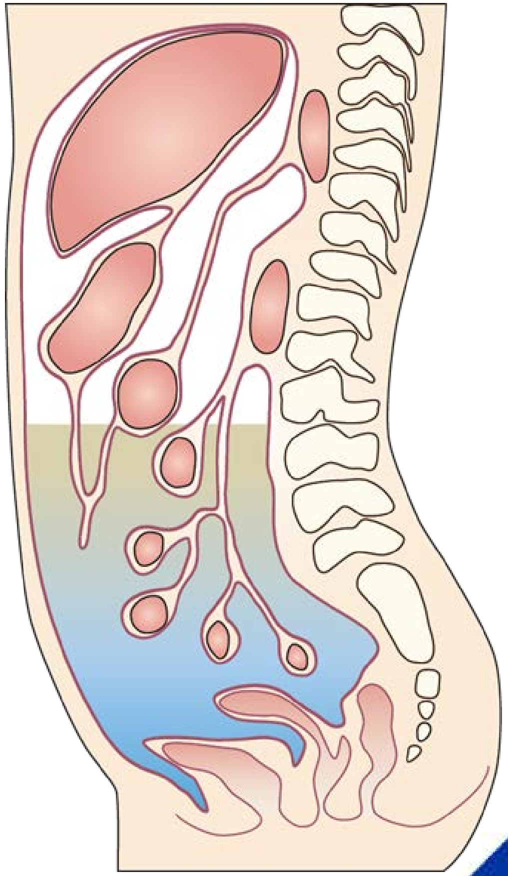
## Cycler Prescription

- Nightly Intermittent PD (NIPD)
  - 2 L fill volume
  - 3 exchanges per night
  - 3-hours per exchange
- Time on dialysis:  9-hr on cycler during the night
- Estimated Kt/V: 2.1
- Considerations:
  - Each exchange targeted for peak UF time with 1.5% dextrose
  - Adequate Kt/V
  - Free day

## Manual Prescription

- Manuals with dry overnight
  - 1.5 L fill volume
  - 3 exchanges per day
  - 5-hour exchanges
- Time on dialysis: 15 hours; i.e. from breakfast to dinner
- Estimated Kt/V: 2.1
- Considerations:
  - Low volume to provide comfort during day
  - Exchanges somewhat longer to adapt to time between breakfast and dinner
  - Dwell time still appropriate for 1.5% glucose
  - Adequate Kt/V
  - Free night, no need for cycler

# Evaluating the Initial PD Prescription



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# 4-8 Weeks After PD Start

## Assess

- Peritoneal transport status
- Clearance & RRF
- UF & Fluid Status
- Clinical status
- Intraperitoneal Pressure

## Modify

- Dwell times
- Fill volumes
- Glucose concentrations
- PD Modality

K/DOQI . *Am J Kidney Dis*. 2006;48 Suppl 1:S91-S97

# Recommending Testing Timelines

## Small Solute Clearance

- First month on dialysis
- At least every 4 months after
- Every 2 months in patients with residual renal function
- When clinically indicated

## Peritoneal Membrane Status

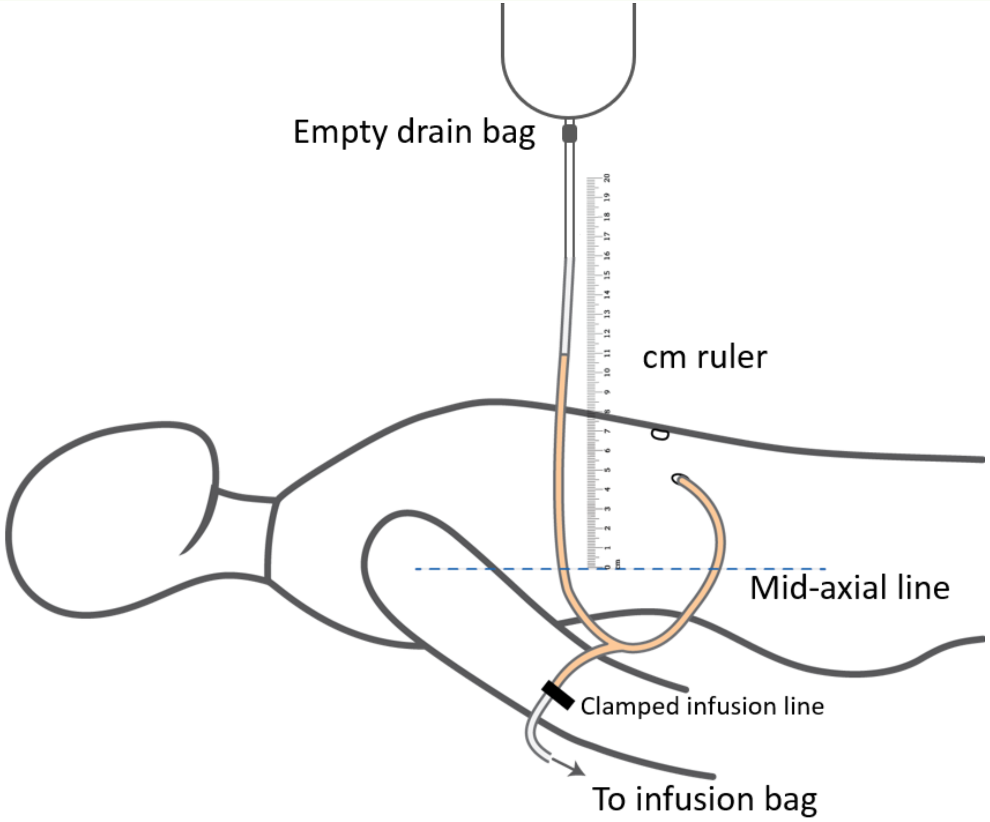
- 4-8 weeks after PD initiation
- Changes in clearance or ultrafiltration
- Volume overload or increased need for hypertonic dialysate solutions
- Clinical symptoms of uremia or worsening hypertension


- K/DOQI . *Am J Kidney Dis*. 2006;48 Suppl 1:S91-S97
- Lo W-K, et al. *Perit Dial Int*. 2006;26(5):520-522

# Determining Intraperitoneal Pressure

IPP > 18 $cmH_20$ becomes clinically symptomatic.
Normal IPP values range from 10-15 $cmH_20$.

1. Have the patient lie in a perfectly horizontal position after instilling the dialysate
2. Set the zero level of the ruler to the mid-axillary line
3. Ensure infusion line is closed
4. Hang the drainage bag on a stand
5. Open the drain line and ensure the extension set is unclamped; the drain line will fill with effluent
6. Wait until the level of fluid in the drain line is stabilized with the patient breathing normally
7. Record $IPP_{insp}$ and $IPP_{exp}$ and average the two values
8. After measurements, lower the drain bag and drain the patient
9. Record drain volume





- Durand P-Y. *Perit Dial Int*. 2005;25(4):333-337
- Mathieu B, Pillot A. *Adv Perit Dial*. 1994;10:59-62

# Case Study: Post-PET Adjustments

- Mr. R has been dialyzing for 6 weeks
- Adequacy Results:
  - **Renal Kt/V: 1.1**
  - **Peritoneal Kt/V: 0.8**
  - **Total Kt/V: 1.9**
- Height: 183 cm, Weight: 88 kg
- PET results: **High Average**
- Would consider to learning the cycler

# Case Study: Post-PET Adjustments

**1** Patient Specifics

2

3

4

- Mr. R is an 82-year-old retired male
- Height: 183 cm, Weight: 88 kg
- Transport type: **High-Average**
- Renal **Kt/V: 1.1**

**1. Patient Data**

Age

82

Gender

Male

Height

183 — ● cm ○ in

Weight

88 — ● kg ○ lb

Transport Status

High Average

Residual Renal Function

1.1 — ● $K_{renal}t/V$ ○ mL/min

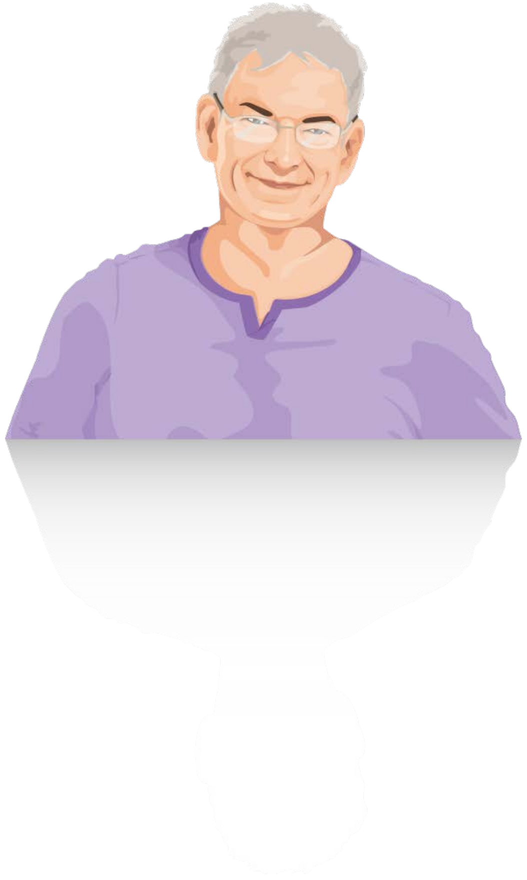
# How does the time to peak UF change?

1 Patient Specifics

2 Dwell Volume

3 Dwell Time

4 Model Options



A. Stays the same
B. Gets shorter
C. Gets longer

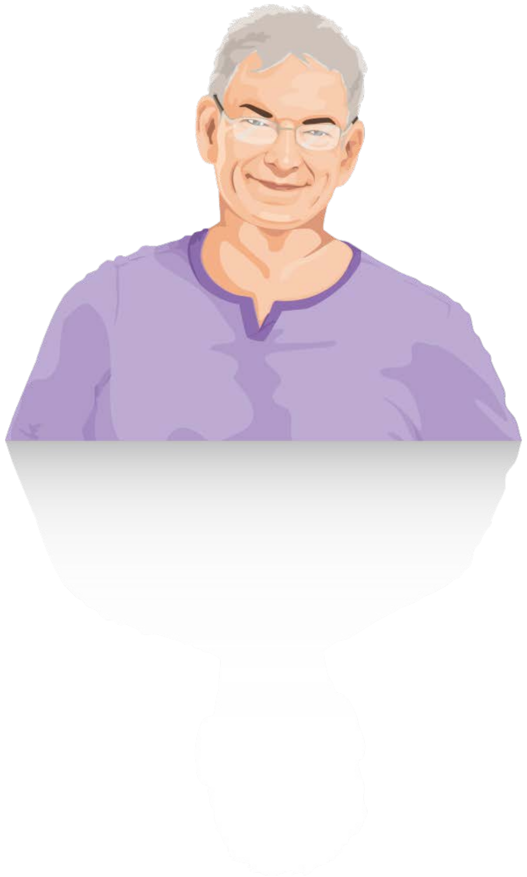
# How does the time to peak UF change?

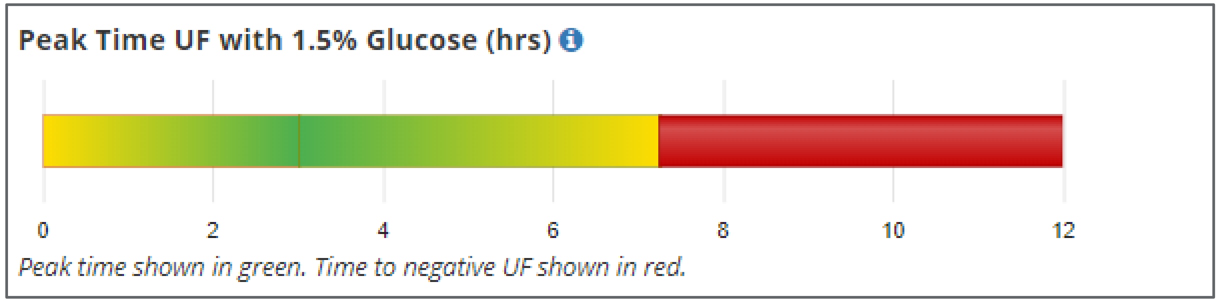
**1** Patient Specifics

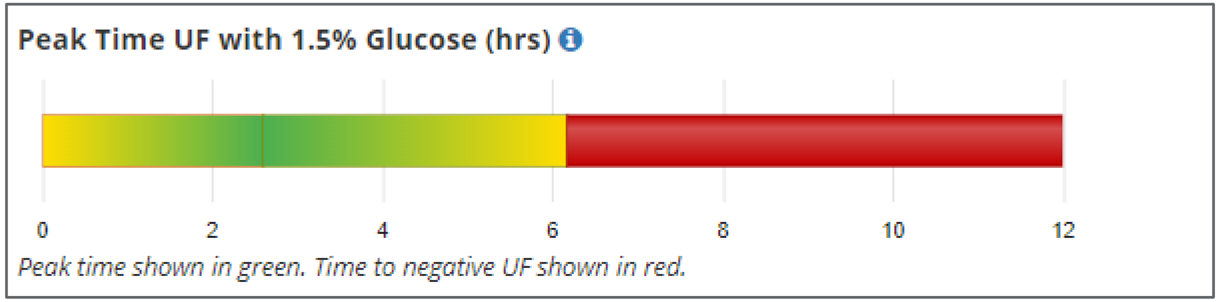
**2** Dwell Volume

**3** Dwell Time

**4** Model Options





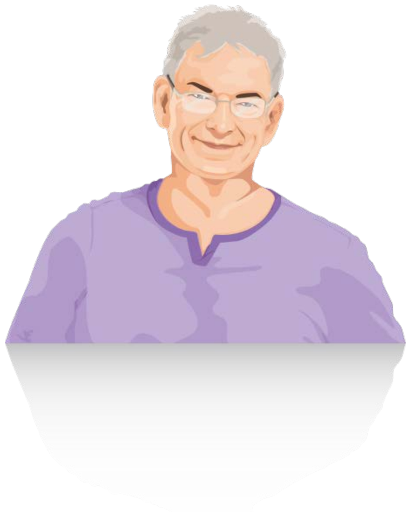
# Should his current prescription be changed?

**1** Patient Specifics

**2** Dwell Volume

**3** Dwell Time

**4** Model Options



A. Yes

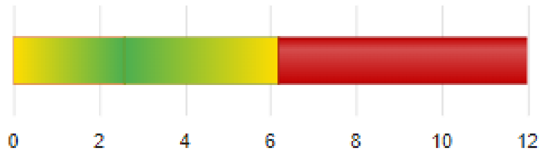
B. No

**2. Estimated Prescription Data**

**Max. Fill Volume (L)**
3 L

**Min. Number Of Exchanges (per day)**
2

**Peak Time UF with 1.5% Glucose (hrs)**




*Peak time shown in green. Time to negative UF shown in red.*

**Min. Total Daily Volume (L)**
6.9

**BSA:** 2.1 $m^2$

**Urea Distribution Volume:** 45 L

**Renal Weekly Kt/V:** 1.1

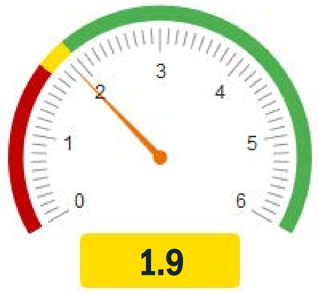
**3. Physician Modeling**

| Daytime | Nighttime |
|---|---|
| **Desired Fill Volume (L)** | **Desired Fill Volume (L)** |
| 1.5 | |
| **Desired Number Of Day Exchanges** | **Desired Number Of Night Exchanges** |
| 3 | |
| **Desired Time Per Exchange** | **Desired Time Per Exchange** |
| 5 hours | Select |

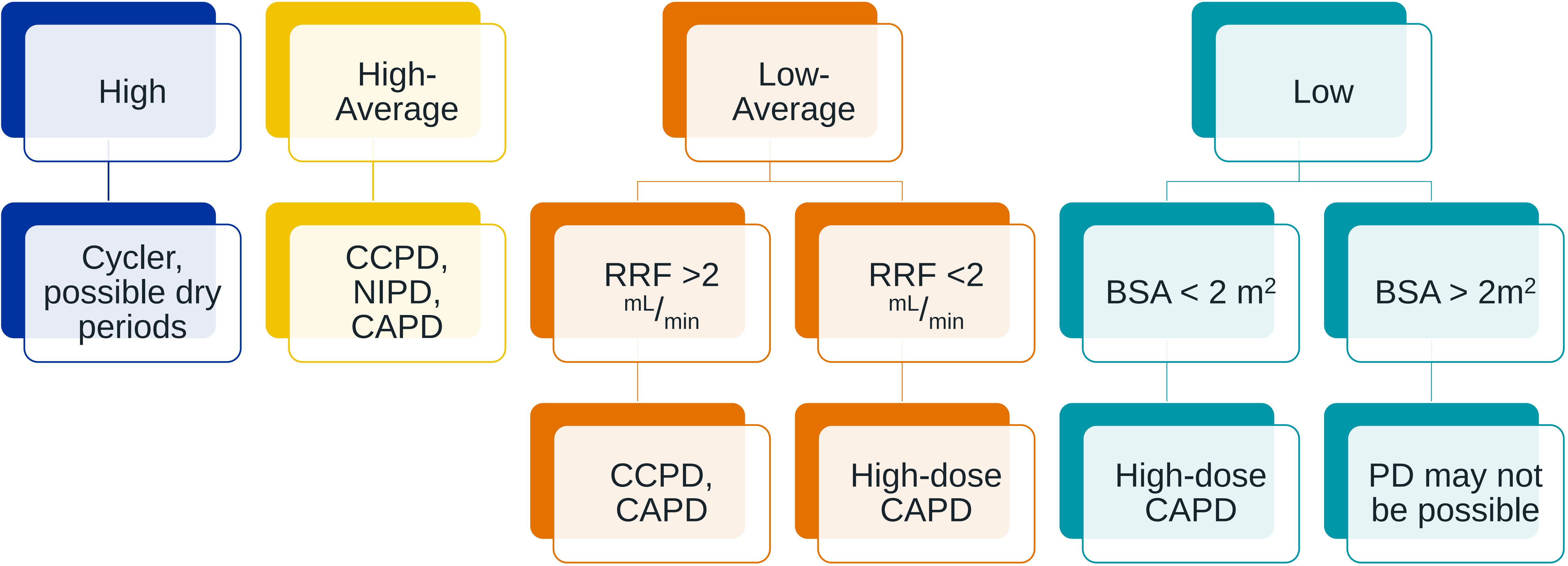
4.5 L *total volume*

15 hours *total time*

**Est. Total Weekly Kt/V**



# General Modality Considerations Based on Transport Type, RRF and Body Size




- Misra M, Khanna R. Peritoneal Equilibration Test. *UpToDate*. 2018;Topic 1972(Version 14.0)

# Possible Adjusted Prescription

1 Patient Specifics

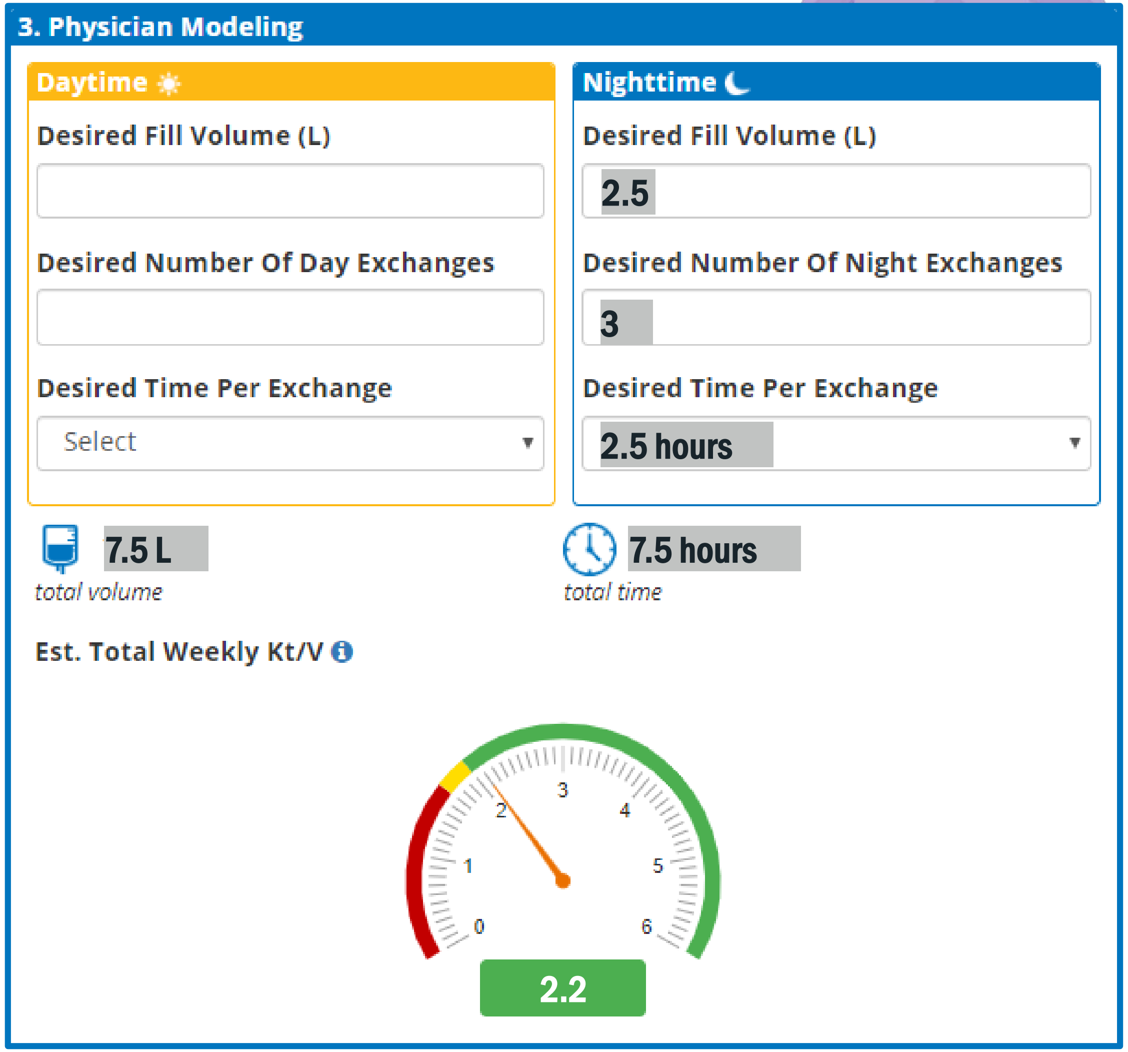
2 Dwell Volume

3 Dwell Time

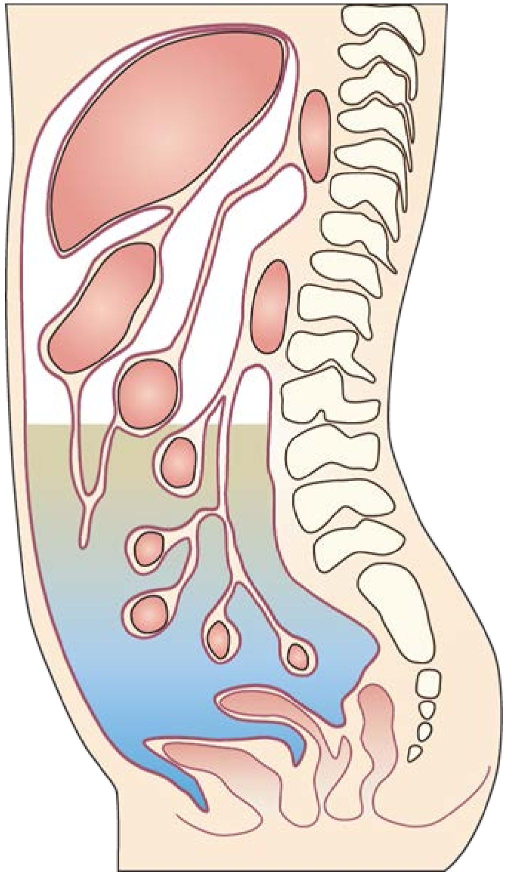
4 Model Options

## APD (NIPD)

- Increased fill volume
  - Since catheter healed in and supine position
- Shortened exchanges to 2.5 h
  - Accounts for transport status
  - Adjusts for max UF per 1.5% glucose exchange
  - Dry day
- Time on dialysis: 7.5 hr
- Estimated Kt/V: 2.2



# Intensifying the PD Prescription



# When to Intensify Dialysis

- Volume overload
- Loss of RRF
- Hyperkalemia
- Hyper-phosphatemia
- Metabolic acidosis
- Anemia
- Uremic neuropathy
- Uremic pericarditis
- Pruritus
- Nausea or vomiting
- Sleep disturbances (restless leg syndrome)

K/DOQI. *Am J Kidney Dis*. 2006;48 Suppl 1:S91-S97

# Intensifying the PD Prescription

| Clearance | Ultrafiltration |
| --- | --- |
| • ↑ # of exchanges<br>• Adjust dwell time<br>• ↑ Fill volume<br>• Change modality | • Adjust dwell time<br>• ↑ Osmotic strength<br>• ↓ IPP<br>• Dietary restrictions |

K/DOQI. *Am J Kidney Dis*. 2006;48 Suppl 1:S91-S97

# Case Study: Loss of RRF

- Mr. R has been dialyzing for 15 months
- Adequacy Results:
  - **Renal Kt/V: 0**
  - **Peritoneal Kt/V: 1.1**
  - **Total Kt/V: 1.1***
- Height: 183 cm, Weight: 88 kg
- PET results: **High Average**

* Obviously, this prescription should have been adjusted earlier. This is a didactic example to demonstrate how much Kt/V may decrease if prescription is not regularly adjusted.

# Case Study: Lost RRF

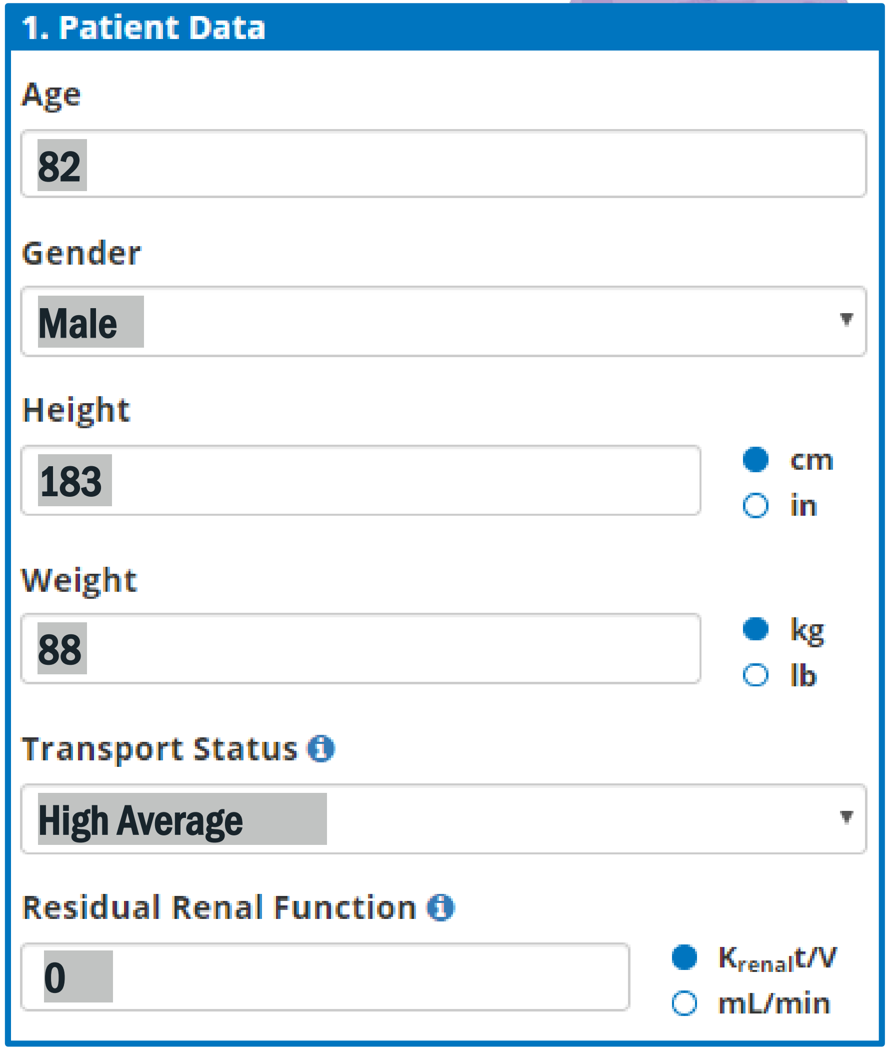
**1** Patient Specifics

2

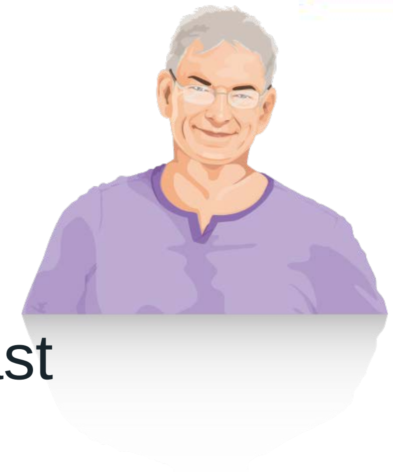
3

4

- Mr. R is an 83-year-old, retired
- Height: 183 cm, Weight: 88 kg
- Transport type: **High-Average**
- Renal **Kt/V: 0**



# What prescription would you pick?



**1** Patient Specifics

**2** Dwell Volume

**3** Dwell Time

**4** Model Options

A. **CCPD** with 4 x 2.8 L, 2.5-hr dwells with 1.5% glc;last fill of 2.3 L with 4.25% or icodextrin

B. **PD Plus™** with 4 x 2.5 L, 2-hr dwells with 1.5% glc; 2-day exchanges of 2L with 2.5% glc

C. **CCPD** with 6 x 2.5 L, 1.5-hr dwells with 1.5% glc; last fill of 2.0 L with 4.25% glc or icodextrin

D. **NIPD** with 8 x 3 L, 1-hr dwells with 1.5% glc; dry day

# Possible PD Plus Prescription

**1** Patient Specifics

**2** Dwell Volume

**3** Dwell Time

**4** Model Options

- Mr. R wants to try PD Plus
- Since retired and home he does not mind the extra day exchange
- He likes the shorter night and low fill volumes

**2. Estimated Prescription Data**

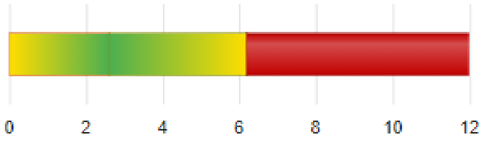
Max. Fill Volume (L)

3 L

Min. Number Of Exchanges (per day)

6

Peak Time UF with 1.5% Glucose (hrs)




*Peak time shown in green. Time to negative UF shown in red.*

Min. Total Daily Volume (L)

15.4

BSA: 2.1 $m^2$

Urea Distribution Volume: 45 L

Renal Weekly Kt/V: 0

**3. Physician Modeling**

**Daytime**

Desired Fill Volume (L)

2

Desired Number Of Day Exchanges

2

Desired Time Per Exchange

8 hours

**Nighttime**

Desired Fill Volume (L)

2.5

Desired Number Of Night Exchanges

4

Desired Time Per Exchange

2 hours

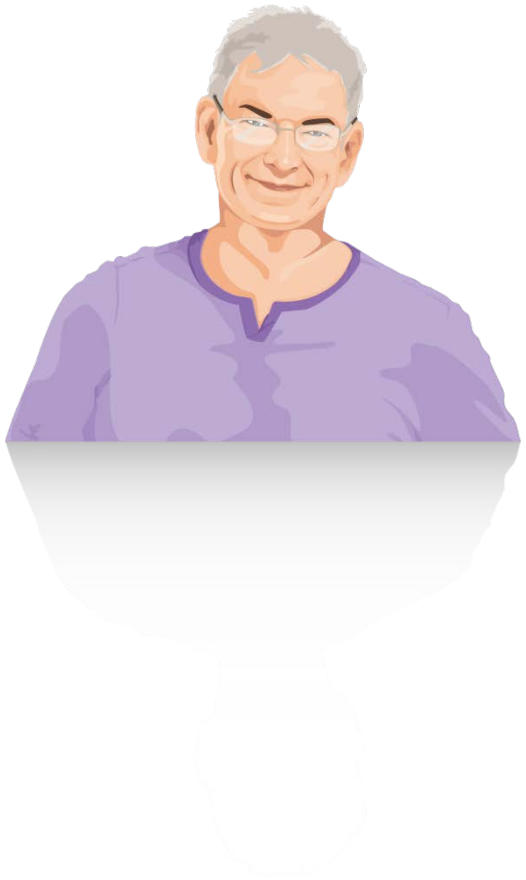
14 L *total volume*

24 hours *total time*

Est. Total Weekly Kt/V

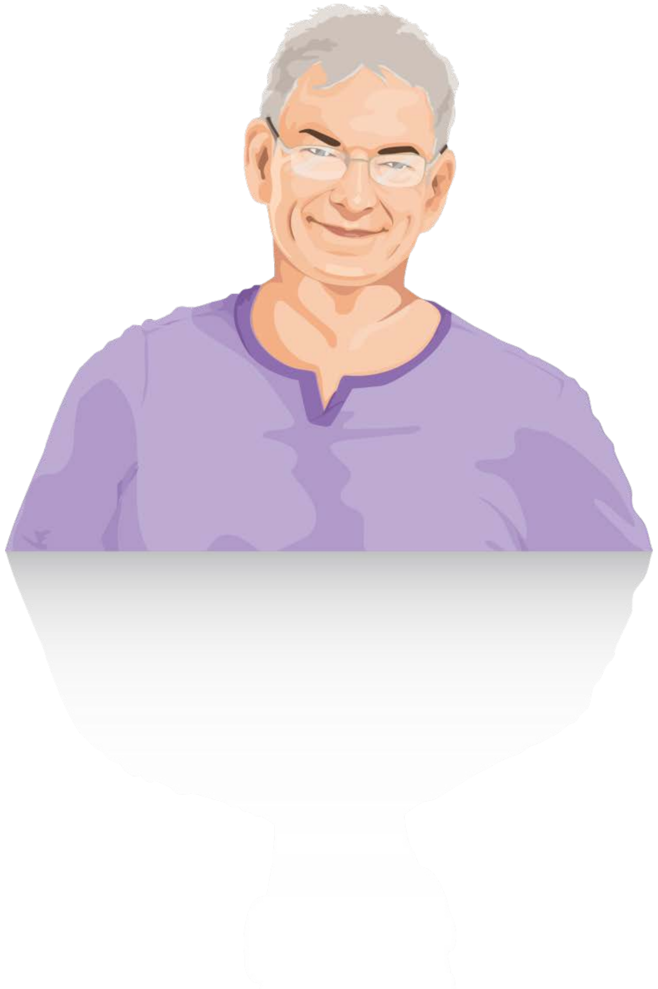

1.9

# Case Study: Hospitalization for Fluid Overload



- Mr. R has been feeling increasingly ill and presents with a pronounced increase in weight
- Admitted to the hospital for complications related to severe fluid overload
- Height: 183 cm, Weight: **93 kg (dry weight 88)**
  - Resident nephrologist prescribes 6 x 2 L, 1-hr dwells with 4.25% dextrose to pull fluid off
  - After 4 exchanges, Mr. R complains of severe thirst, nausea, and muscle spasms

# What happened?



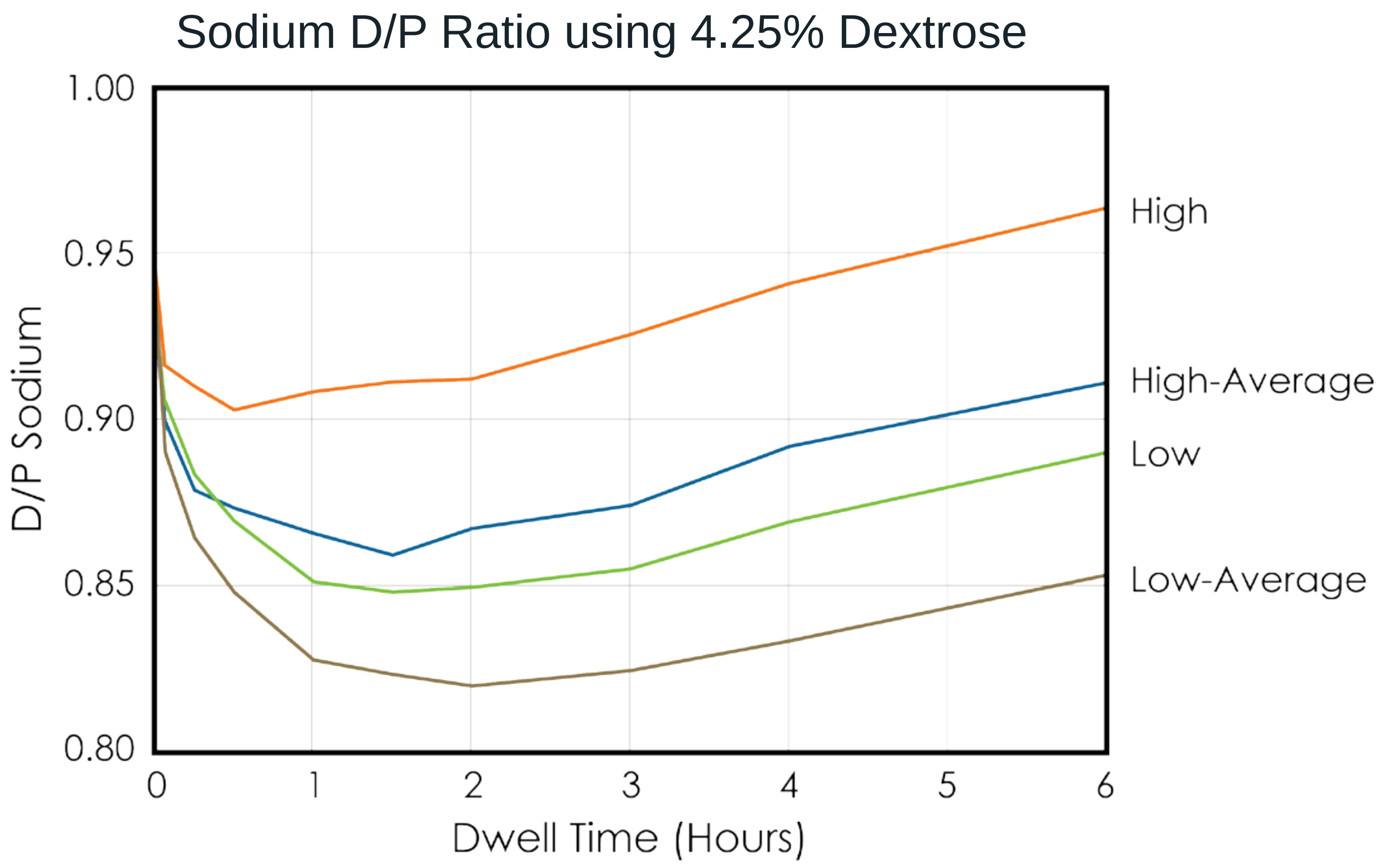
A. Fluid was removed too fast and patient became hypovolemic

B. The dwell times were too short and patient became hypernatremic

C. The dwell times were too long and he remained hypervolemic

D. None of the above.

# Sodium Sieving in Peritoneal Dialysis

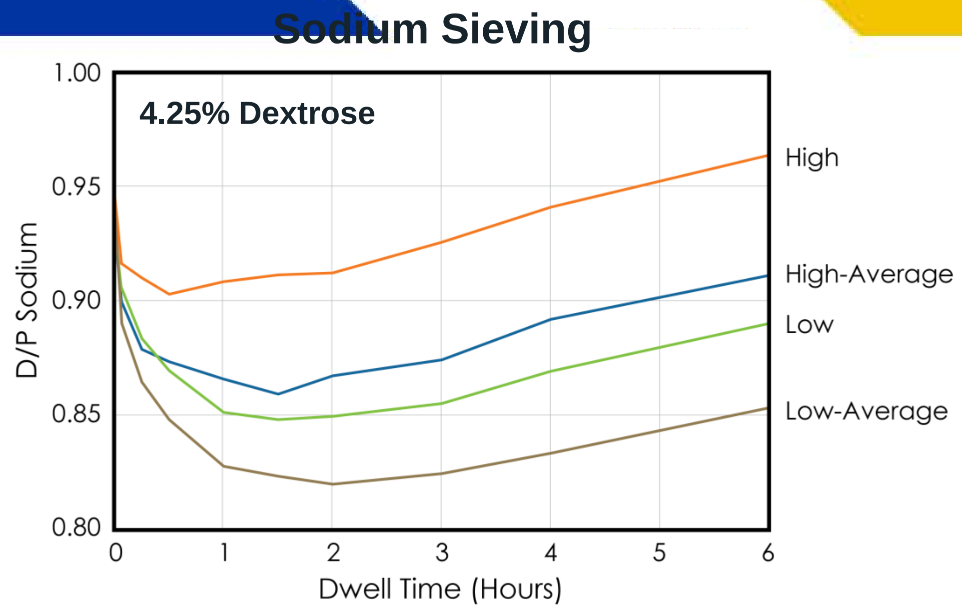


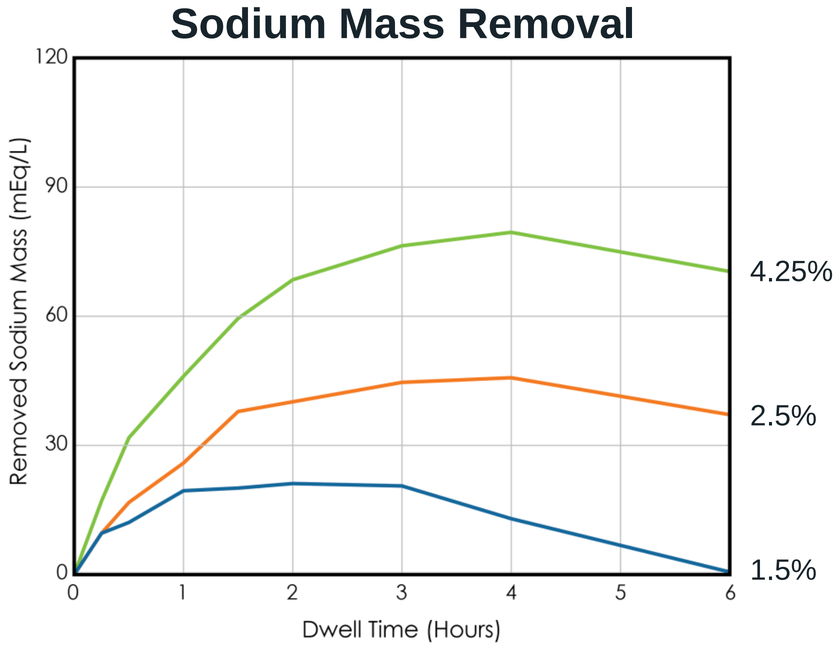

- Due to free water transport at the beginning of a dwell:
  - Dialysate sodium is diluted
  - Plasma sodium is "sieved" and becomes more concentrated
  - Relevant especially early in the dwell
- Note: sodium sieving looks at the *concentration* of sodium not at the *amount* removed

- Wang T, et al. *Kidney Int*. 1997;52(6):1609-1616

# Sodium Removal in PD

- Mainly depends on 2 variables:
    - Sodium sieving and Ultrafiltration
- Sieving peaks in the first 1-2 hours and then steadily improves
- This seems to indicate the longer the dwell the better the sodium removal
- However sodium removal depends most strongly on UF
    - Total sodium removal declines in long dwells after peak UF is reached
- Sieving impairs sodium removal in too short cycles, reabsorption in too long cycles



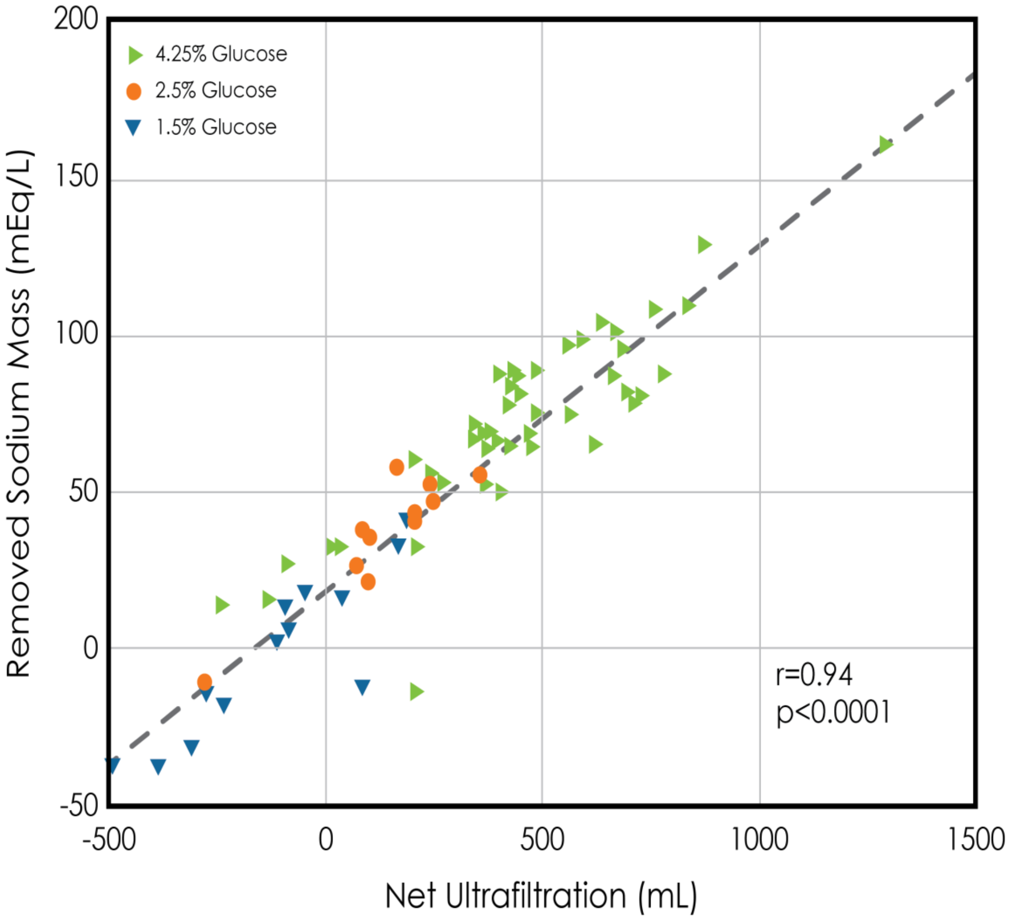




- Wang T, et al. *Kidney Int*. 1997;52(6):1609-1616

# Sodium Removal

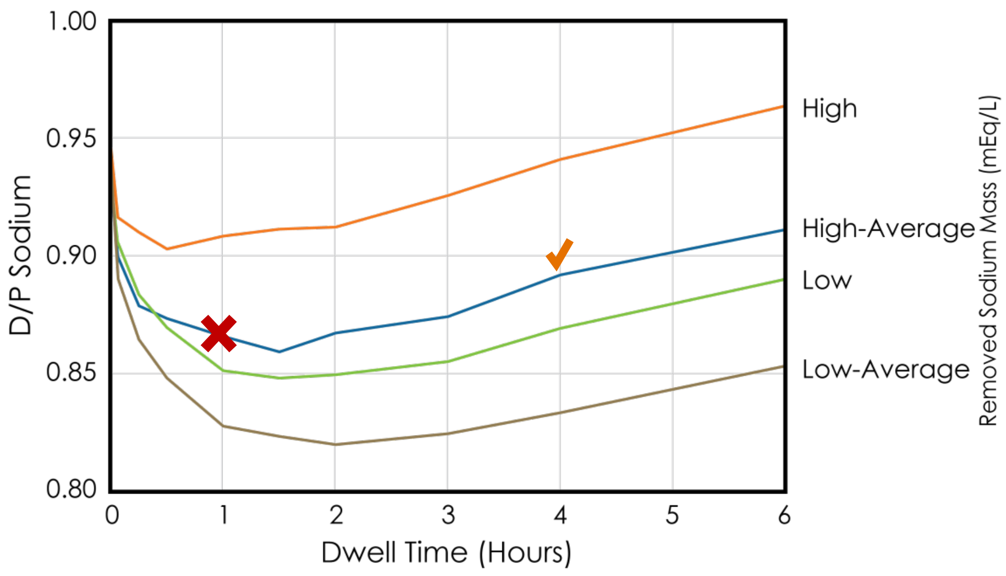
- Sodium removal correlates heavily with ultrafiltration volume
  - No significant concentration gradient for sodium
  - Sodium removal thus largely dependent on convective transport
  - Convective transport depends on UF rate
  - Sodium removal peaks around the same time peak ultrafiltration is reached with each dextrose concentration
- **Bottom line**: Maximizing prescription for time to peak UF also maximizes sodium removal

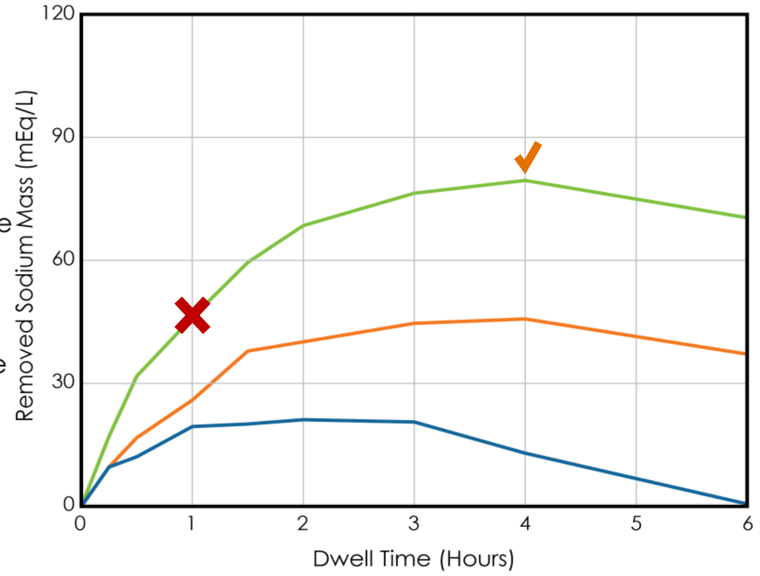
**Correlation of Sodium Removal with UF**




- Wang T, et al. *Kidney Int*. 1997;52(6):1609-1616

# Case Study: Hospitalization for Fluid Overload



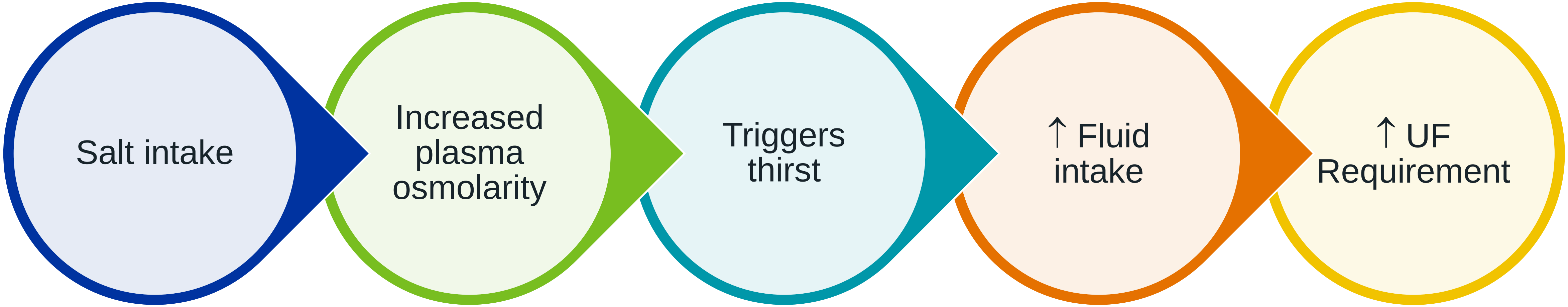




- The dwell time of 1-hr with a 4.25% glucose solution resulted in marked sodium sieving as indicated by the red crosses
- The repeated short cycles with high dextrose solution lead to hypernatremia
- A change in the regimen to 4-hr dwells achieved adequate sodium and fluid removal and resolved the hypernatremia
- Mr. R was discharged after 2 days

Wang T, et al. *Kidney Int*. 1997;52(6):1609-1616

# Dietary Sodium Restriction

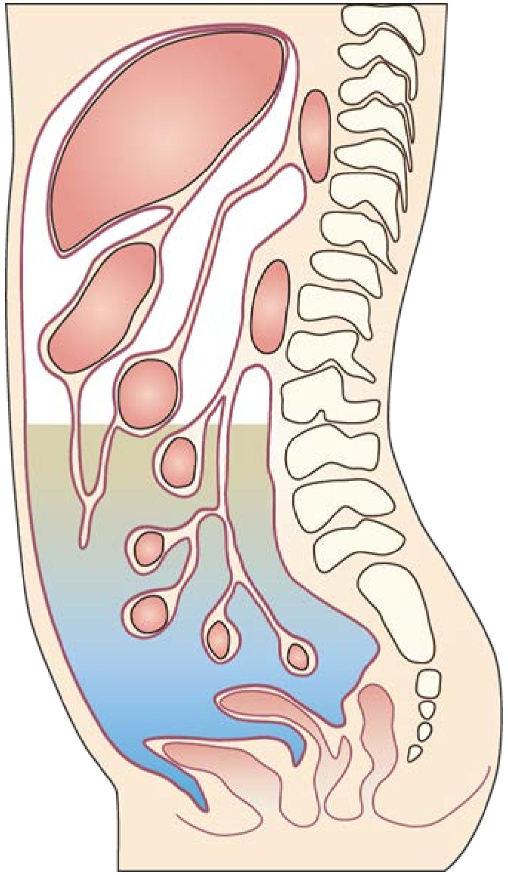
Reinforce importance of dietary sodium intake and fluid restrictions





- Santos SFF, Peixoto AJ. *Semin Dial.* 2010;23(6):549-555
- Lindley EJ. *Semin Dial.* 2009;22(3):260-263

# Clinical Takeaways



- ✓ Don’t assume 4 x 2L exchanges is ideal for all patients
- ✓ Customize prescription to clinical needs and patient transport type
- ✓ Assess more than Kt/V when determining adequacy
- Optimize dwell time for peak UF which is also best for sodium removal
- ✓ Avoid very short dwell times that may result in sodium sieving
- Avoid dwell times that are too long and result in fluid reabsorption and negative UF

# Questions?

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