

Peritoneal Dialysis Prescription and Adequacy Monitoring

Annabelle N. Chua, MD

March 3, 2023

Disclosures

No financial disclosures relevant to this talk

Acknowledgment:

Some slides previously borrowed/modified
from Dr. Christine Sethna

Overview

- Physiology of the peritoneal membrane
- Clinical factors that impact peritoneal dialysis (PD) prescription in the pediatric population
- PD prescription components
- Role of dialysis adequacy to monitor the effectiveness of peritoneal dialysis

Why Peritoneal Dialysis?

Advantages

- Vascular access not required
 - Better for infants/small children
- Improved fluid balance; less antihypertensive medications
- Fewer dietary restrictions
- Relatively safe and simple
- Allows for regular school attendance
- Better growth
- Less travel to dialysis unit

Disadvantages

- Risk of infection (peritonitis, exit site and tunnel infections)
- Hernias
- Labor intensive; increased caregiver burden
 - Risk of non-adherence
- Decreased appetite
- Body image disturbance

Contraindications to PD

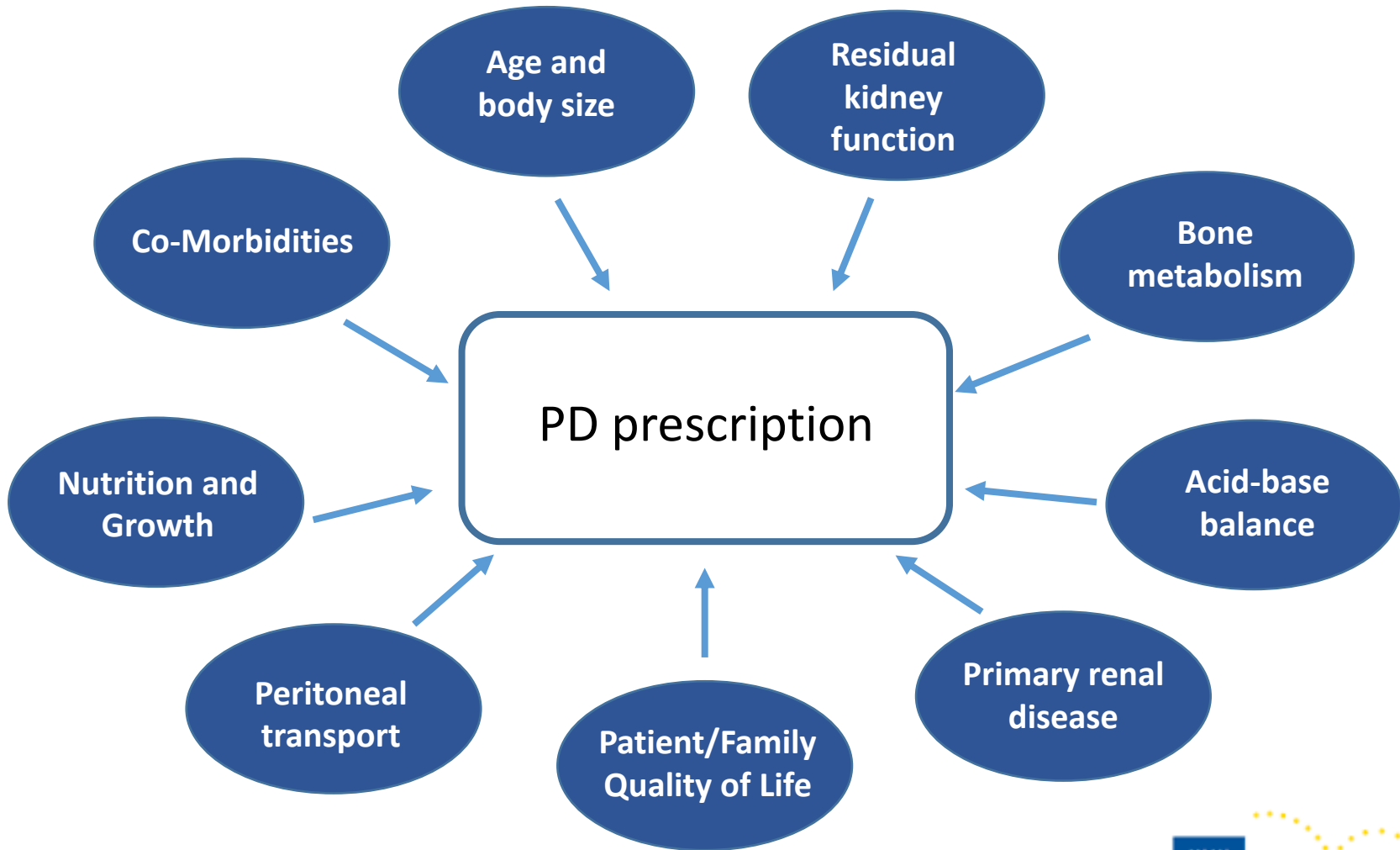
ABSOLUTE

- Omphalocele
- Gastroschisis
- Bladder Exstrophy
- Diaphragmatic hernia
- Obliterated peritoneal cavity
- Peritoneal membrane failure

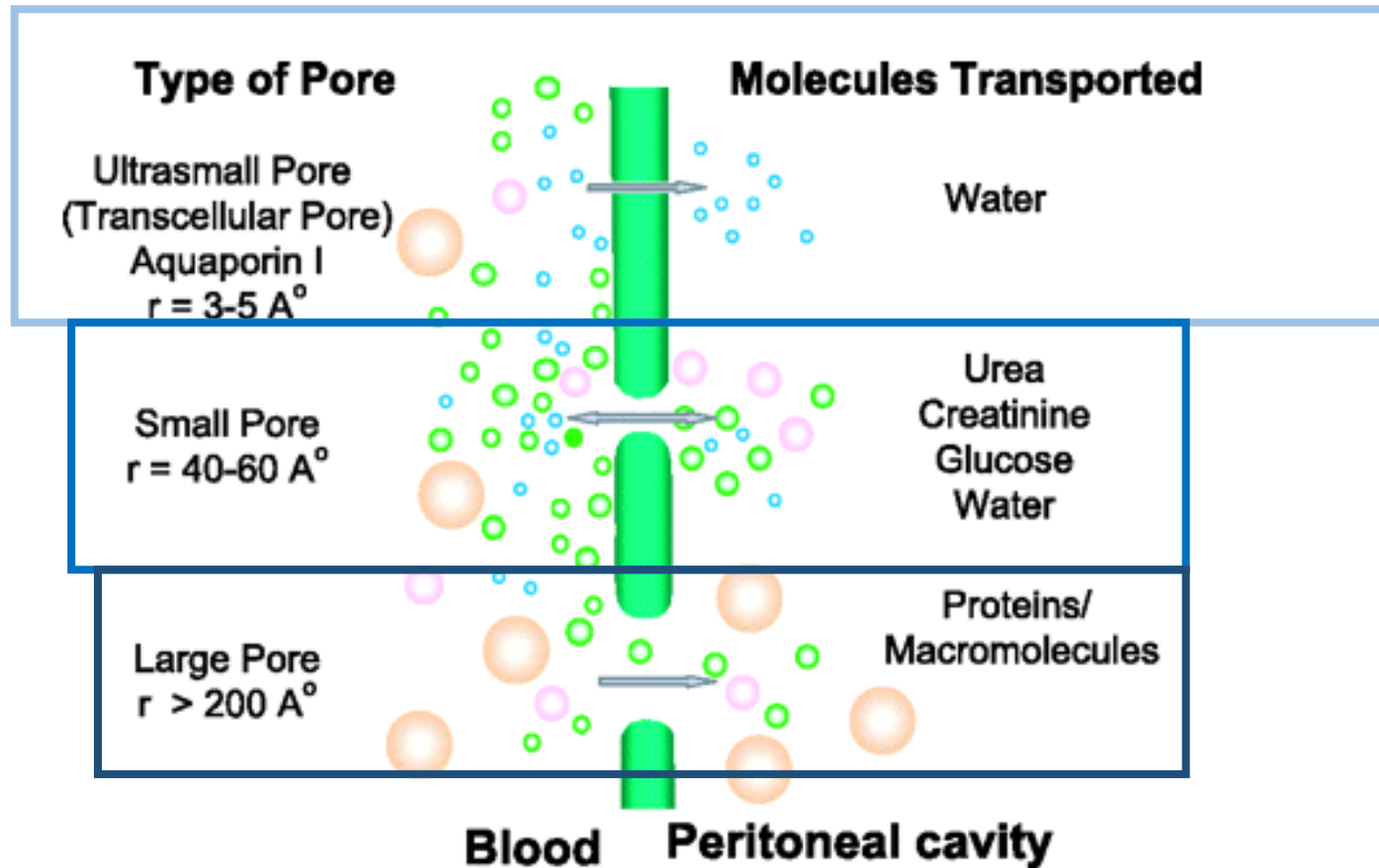
RELATIVE

- Presence of ileostomies and colostomies
- Infants with significant organomegaly
- Impending abdominal surgery
- Lack of appropriate caregiver for home therapy; lack of appropriate home environment
- Impending (<3-6months) living-donor kidney transplantation

PD Prescription



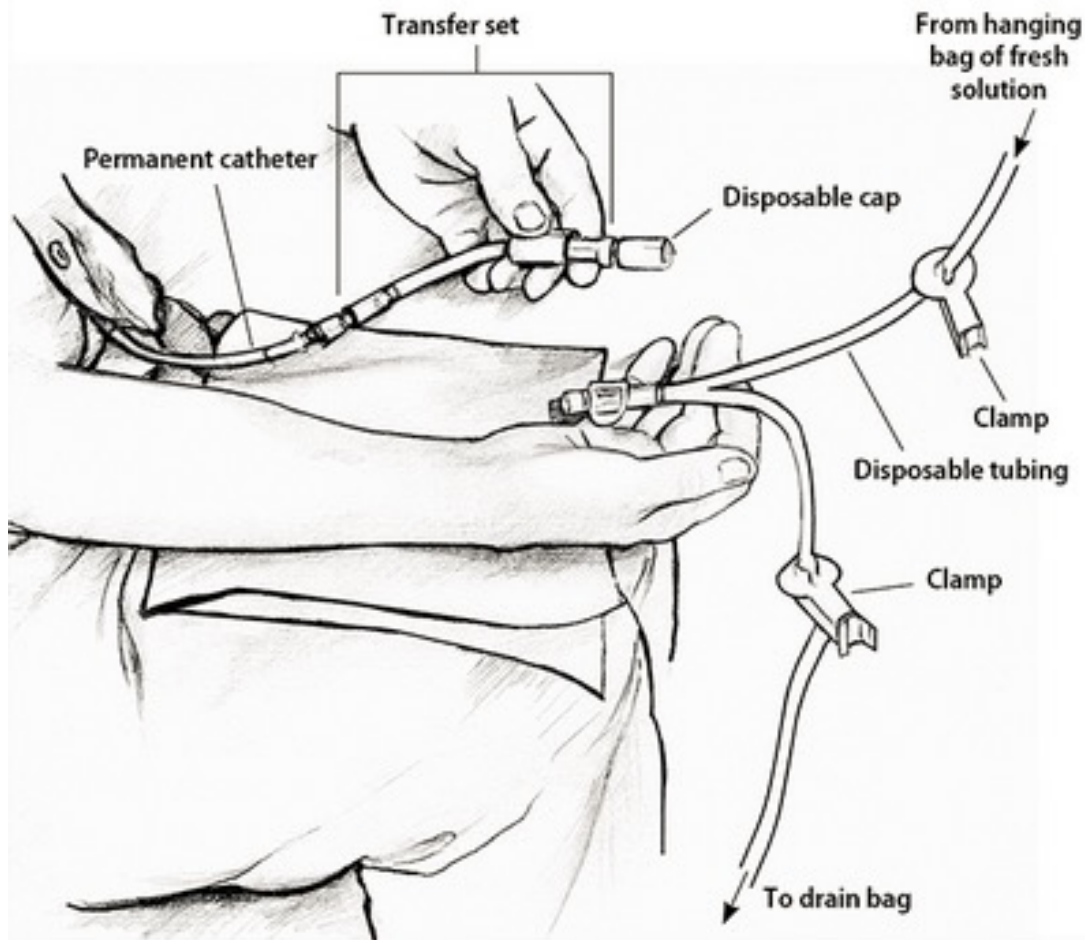
Physiology of Peritoneal Membrane



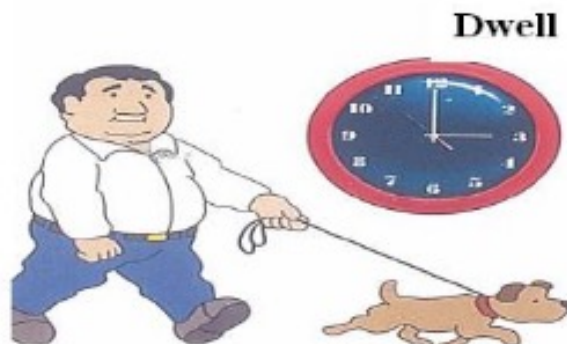
PD Prescription Components

- Modality – CAPD vs APD
- Solution
- Fill volume
- Dwell Time
- Number of Exchanges

Modality – Continuous Ambulatory Peritoneal Dialysis (CAPD)



Modality – Continuous Ambulatory Peritoneal Dialysis (CAPD)



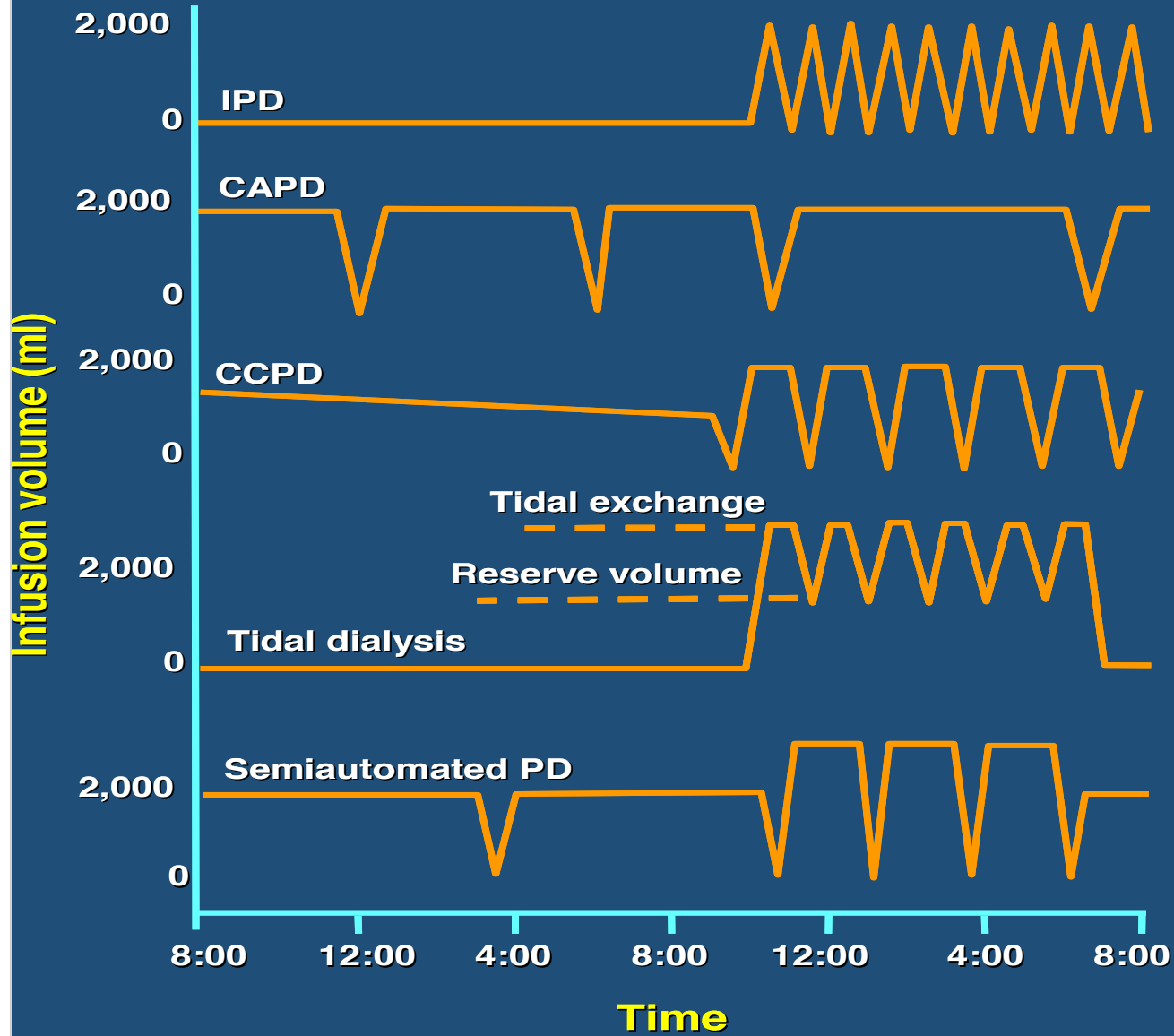
- Provides continuous solute and fluid removal throughout the day and night
- Daytime exchanges ~5 hours
- Nighttime exchange ~9 hours
- Ease of use
- Low cost of equipment
- Often used in developing countries with limited resources available

Modality – Automated Peritoneal Dialysis (APD)

- Continuous Cycling (CCPD)
- Nightly Intermittent (NIPD)
- Tidal (TPD)



Peritoneal dialysis formats



PD Rx: Modality

Determinants of Modality Choice

- Financial
- Center preference
- Geography
- Lifestyle
- Peritoneal membrane transport characteristics

PD Rx: Solution

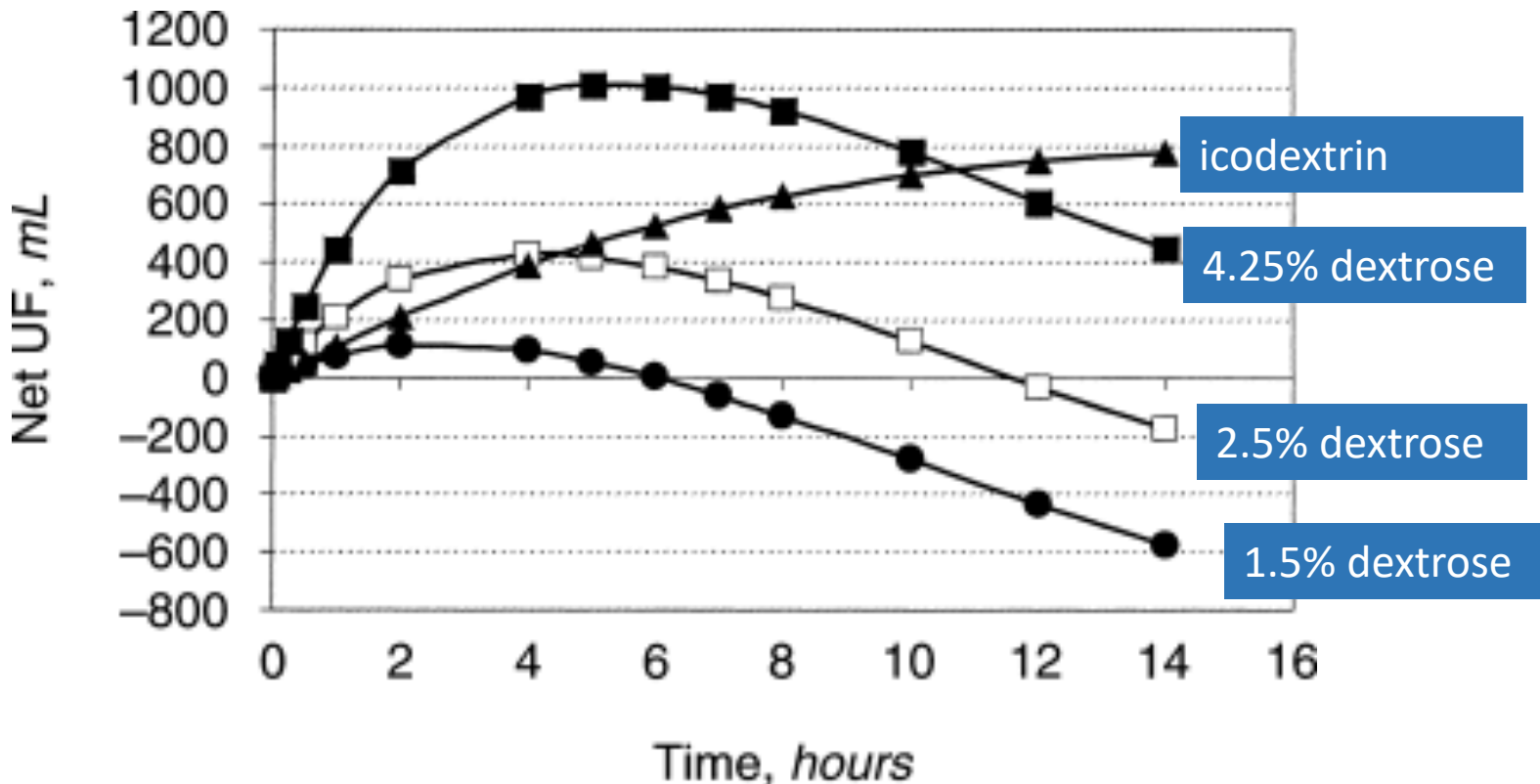
Composition:

- Water
- Osmotic agent
 - Dextrose (1.5%, 2.5%, 4.25%)
 - Icodextrin
 - Amino acids
- Buffer
 - Lactate
 - Bicarbonate



- Electrolytes
 - Sodium 132-134 mEq/L
 - Chloride 96-105 mEq/L
 - Magnesium 0.25-0.5 mEq/L
 - Calcium 2-3.5 mEq/L
 - No potassium
- Additives
 - Heparin
 - Antibiotics

PD Rx: Solution



Solutions

Table 1 | Selected peritoneal dialysis solutions currently available in Europe

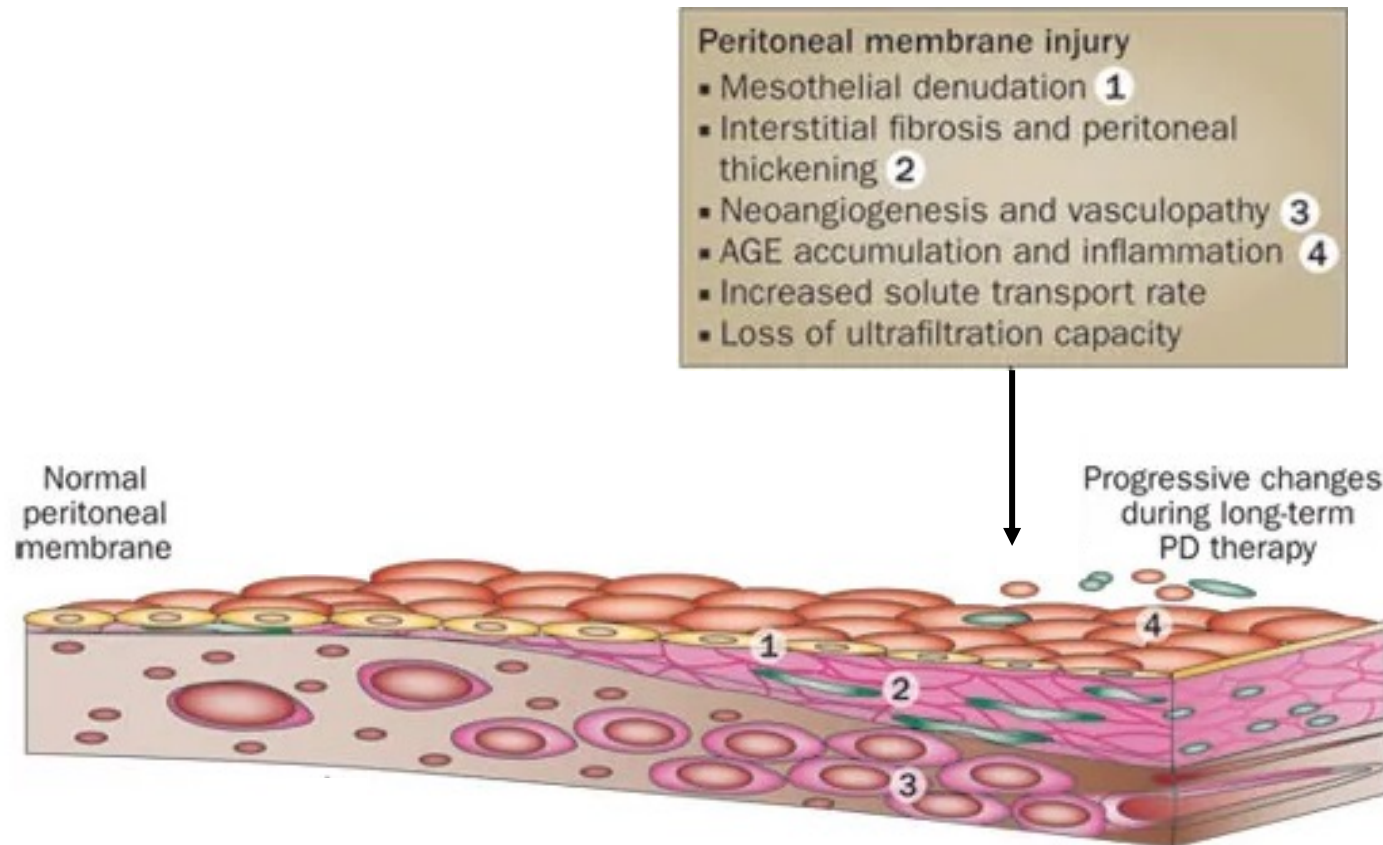
Solution (manufacturer)	pH	Chambers	Buffer	Osmotic agent	GDPs	Advantages	Disadvantages
Dianeal® (Baxter*)	5.2	Single	Lactate	Glucose	High	Easy to manufacture; low cost	Low pH; poor peritoneal membrane biocompatibility; infusion pain; contains lactate
Extraneal® (Baxter*)	5.6	Single	Lactate	Icodextrin	Low	Sustained ultrafiltration; reduced	Contains lactate; low pH; single daily use only; hypersensitivity
Nutrineal® (Baxter*)	5.5	Single	Lactate	Amino acids	No	Improved protein and amino acid nutrition	Contains lactate; low pH; single daily use only
Physioneal® (Baxter*)	7.4	Double	Lactate/bicarbonate	Glucose	Low	Improved biocompatibility; preserved membrane defense; reduced infusion pain	Local and systemic glucose exposure; reduced peritoneal lactate exposure
Stay-safe® (Fresenius‡)	5.5	Single	Lactate	Glucose	High	Ease of manufacture; low cost	Low pH; poor peritoneal membrane biocompatibility; infusion pain; contains lactate
Balance® (Fresenius‡)	7.0	Double	Lactate	Glucose	Low	Improved biocompatibility; preserved membrane defense; reduced risk of peritonitis?	Higher but not neutral pH; local and systemic glucose exposure; contains lactate
BicaVera® (Fresenius‡)	7.4	Double	Bicarbonate	Glucose	Low	Improved biocompatibility; preserved membrane defense; improved correction of acidosis	Local and systemic glucose exposure
Gambrosol® Trio (Fresenius‡)	6.5	Triple	Lactate	Glucose	Low	Improved biocompatibility; preserved membrane defense	Higher but not neutral pH; local and systemic glucose exposure; contains lactate

Glucose degradation products

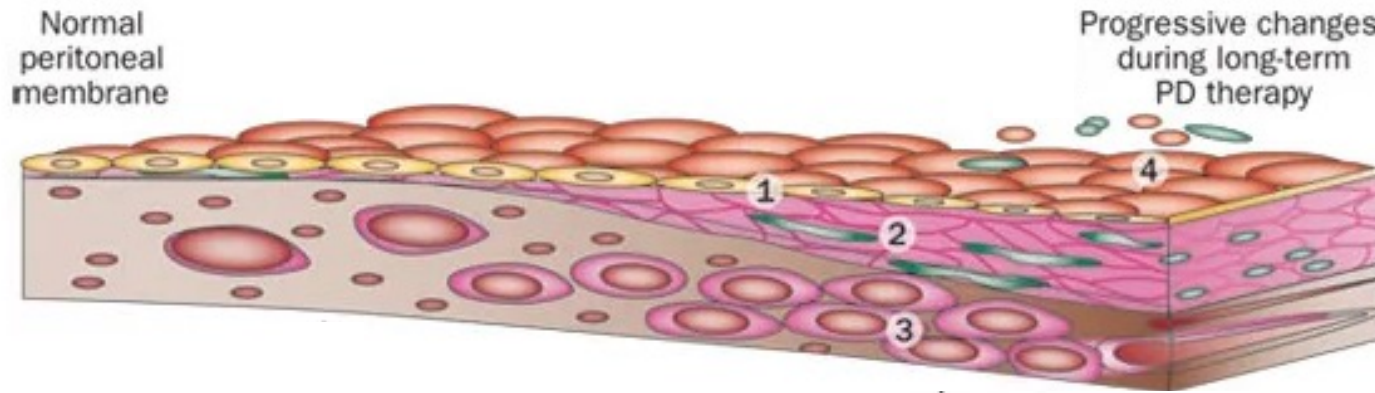
Delflex

*Deerfield, IL, USA. ‡Bad Homburg, Germany. Abbreviation: GDPs, glucose degradation products.

Effects of Conventional Solutions



Effects of Conventional Solutions



Harmful systemic effects

- Fluid and sodium retention
- Left ventricular hypertrophy
- Hyperglycemia
- Hyperinsulinemia
- Hyperlipidemia
- Abdominal obesity

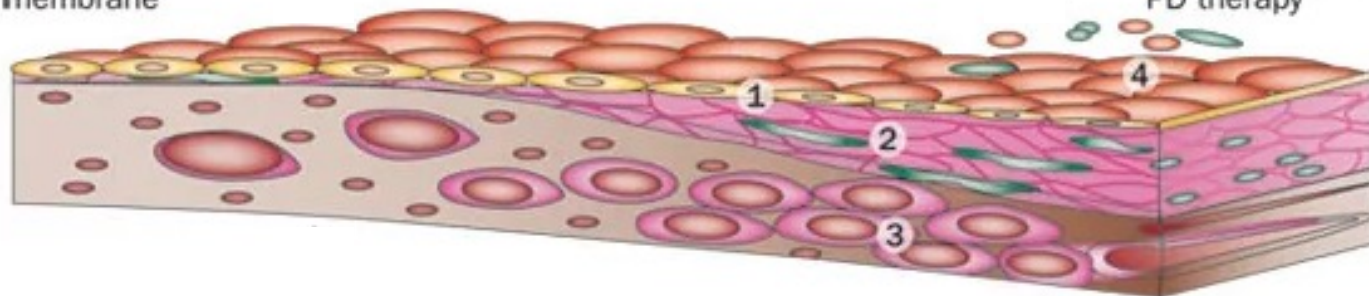
Suboptimal patient and technique survival

Biocompatible Solutions

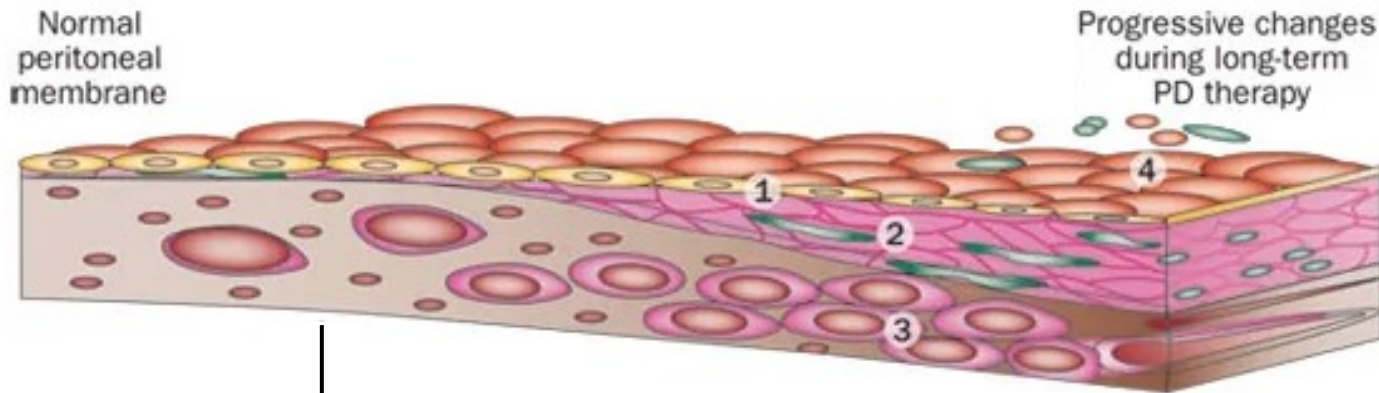
Improved peritoneal membrane viability

- Attenuation of peritoneal fibrosis
- Preservation of peritoneal cell viability and function
- Less AGE accumulation
- Less inflammation

Normal peritoneal membrane



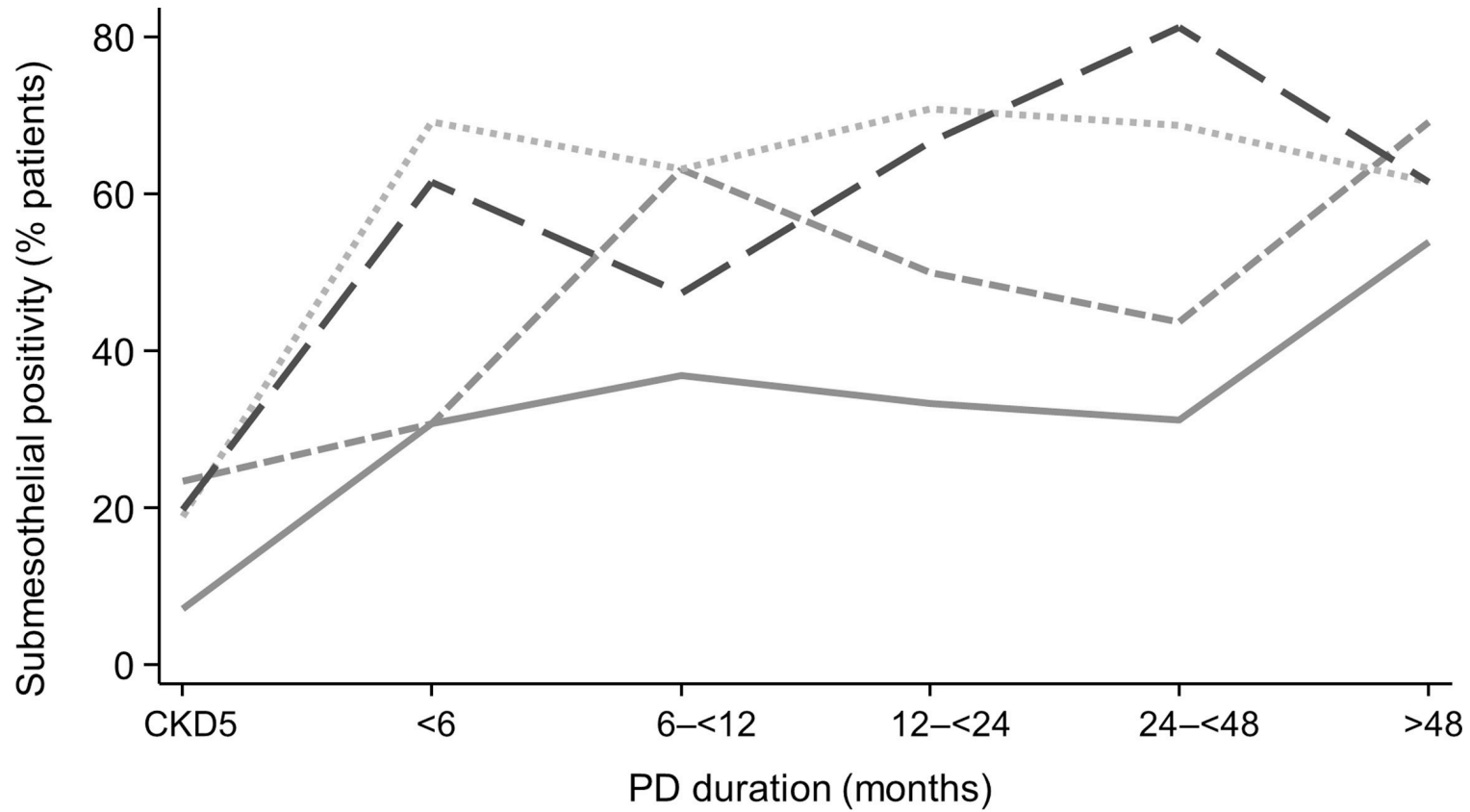
Effects of Biocompatible Solutions



- Improved systemic effects
- Improved metabolic control
 - Improved body composition
 - Improved UF capacity
 - Improved fluid status
 - Preservation of RRF?
 - Reduced peritonitis rate?
 - Reduced systemic inflammation?

Improved patient and technique survival?

Biocompatible Solutions in Children



--- ASMA (fibroblasts) CD45 (leukocytes) -.-.- CD68 (macrophages) _____ EMT

PD Rx: Solution

Risk factors for loss of residual renal function in children treated with chronic peritoneal dialysis

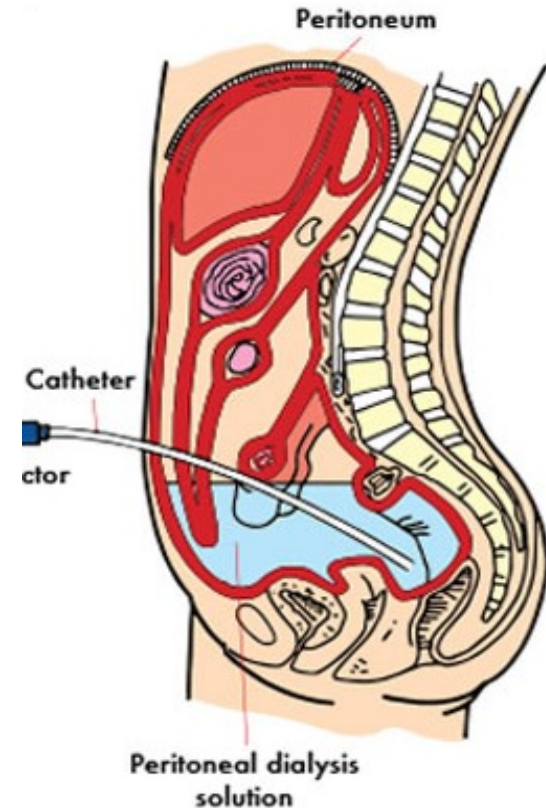
Il-Soo Ha¹, Hui K. Yap², Reyner L. Munarriz³, Pedro H. Zambrano⁴, Joseph T. Flynn⁵, Ilmay Bilge⁶, Maria Szczepanska⁷, Wai-Ming Lai⁸, Zenaida L. Antonio⁹, Ashima Gulati¹⁰, Nakysa Hooman¹¹, Koen van Hoeck¹², Lina M.S. Higueta¹³, Enrico Verrina¹⁴, Günter Klaus¹⁵, Michel Fischbach¹⁶, Mohammed A. Riyami¹⁷, Emilja Sahpazova¹⁸, Anja Sander¹⁹, Bradley A. Warady²⁰ and Franz Schaefer²¹ for the International Pediatric Peritoneal Dialysis Network (IPPN) Registry²²

- Icodextrin associated with increased risk of developing oligoanuria HR 2.38 (1.33-4.2) and lower residual urine output (p=0.043)
- Biocompatible fluid associated with greater residual urine output (p=0.028)

PD Rx: Fill Volume

- Peritoneal membrane area is related to body size
- Use body surface area to calculate fill volume (as opposed to weight)
- Fill volume affects peritoneal membrane recruitment and diffusion capacity

↑ Volume = ↑ Clearance



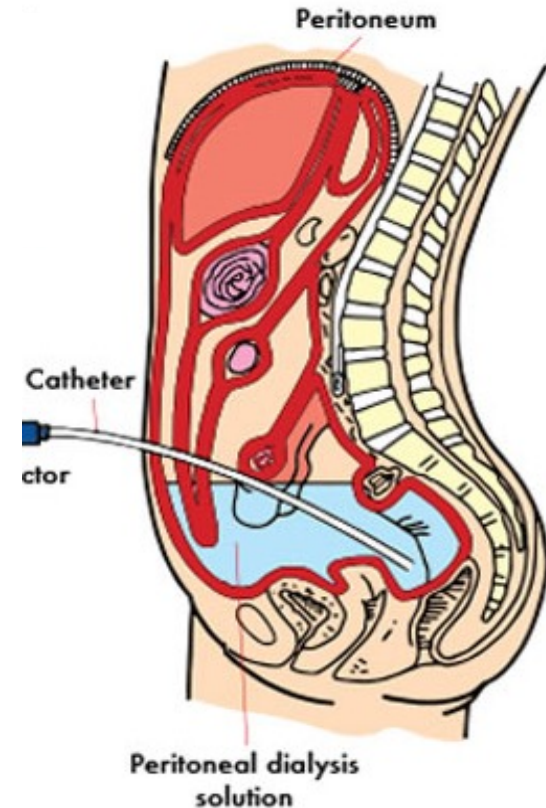
PD Rx: Fill Volume

APD:

- Nocturnal fill volume:
 - >2 years: 1100-1400 mL/m²
 - < 2 years: 600-800 mL/m²
- Daytime Fill volume:
 - 50% of nocturnal fill volume

CAPD:

- 600-800 mL/m² (day)
- 800-1000 mL/m² (night)



Measuring IPP

Intra-peritoneal pressure maximum 18 cm H₂O
Normal 7-14 cm H₂O

- Empty bladder
- Patient placed completely flat
- Connection made to peritoneal system
- Any fluid in abdominal cavity is drained and defined volume of PD fluid is instilled
- PD line is fixed vertically
- Zero level of column (on graduated scale) is set at center of abdominal cavity, on the medial axillary line
- Connection of line to patient is opened
- Level of column of dialysis fluid in the PD line is read with a scale graduated in cm after height of column stabilizes



Fig. 1 The zero level of the column (*on the graduated scale*) is set at the centre of the abdominal cavity, i.e. medial axillary line

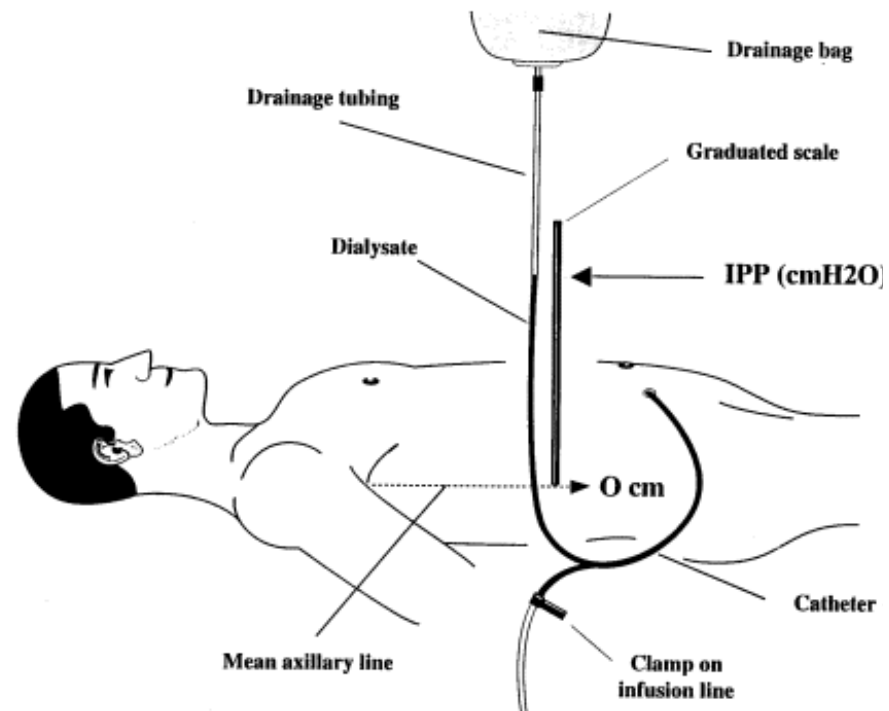
$$\text{Mean IPP} = \frac{\text{IPP insp} + \text{IPP exp}}{2}$$

PD Rx: Excess Volume

Intra-peritoneal pressure maximum 18 cm H₂O
Normal 7-14 cm H₂O

Excess volume:

- Loss of UF
- Pain
- Risk of hernia
- Risk of hydrothorax
- Risk of breathing problems



PD Rx: Dwell Time

Short exchanges

- Clearance of small solutes (urea)
- Better ultrafiltration

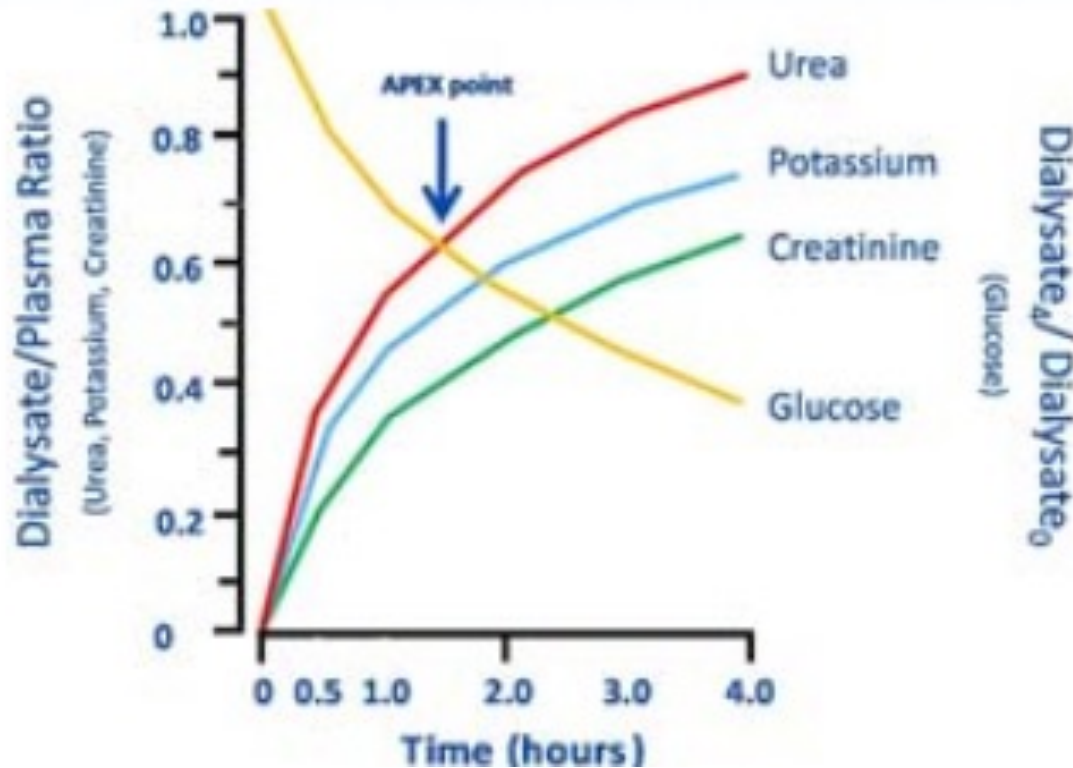
Long exchanges

- Clearance of higher molecular weight (creatinine and phosphate)
- Less ultrafiltration

Dwell time should be determined by individual peritoneal membrane transport status

PD Rx: Dwell Time

Accelerated Peritoneal Examination
APEX time indicates optimal dwell time for UF



PD Rx: # Exchanges

APD

- 5-10 exchanges overnight
- 9-12 hours
- Daytime dwell

CAPD

- 3-5 exchanges/day
- 4-5 hour dwell time, with longer overnight dwell

PD Rx cheat sheet

Automated PD

Solution:

1.5%, 2.5% or 4.25% Dianeal

Fill volume (nocturnal):

< 2 years old = 600-800 mL/m²

> 2 years old = 1100-1400 mL/m²

Last fill (daytime):

1/2 the nocturnal fill volume

#exchanges over #hours:

5-10 exchanges overnight over 9-12 hrs

Fill/Drain time: 15 minutes

Dwell time: 40-60 minutes

CAPD

Solution:

1.5%, 2.5% or 4.25% Dianeal

Fill volume (daytime):

600-800 mL/m²

Long overnight dwell(nocturnal):

800-1000 mL/m²

exchanges:

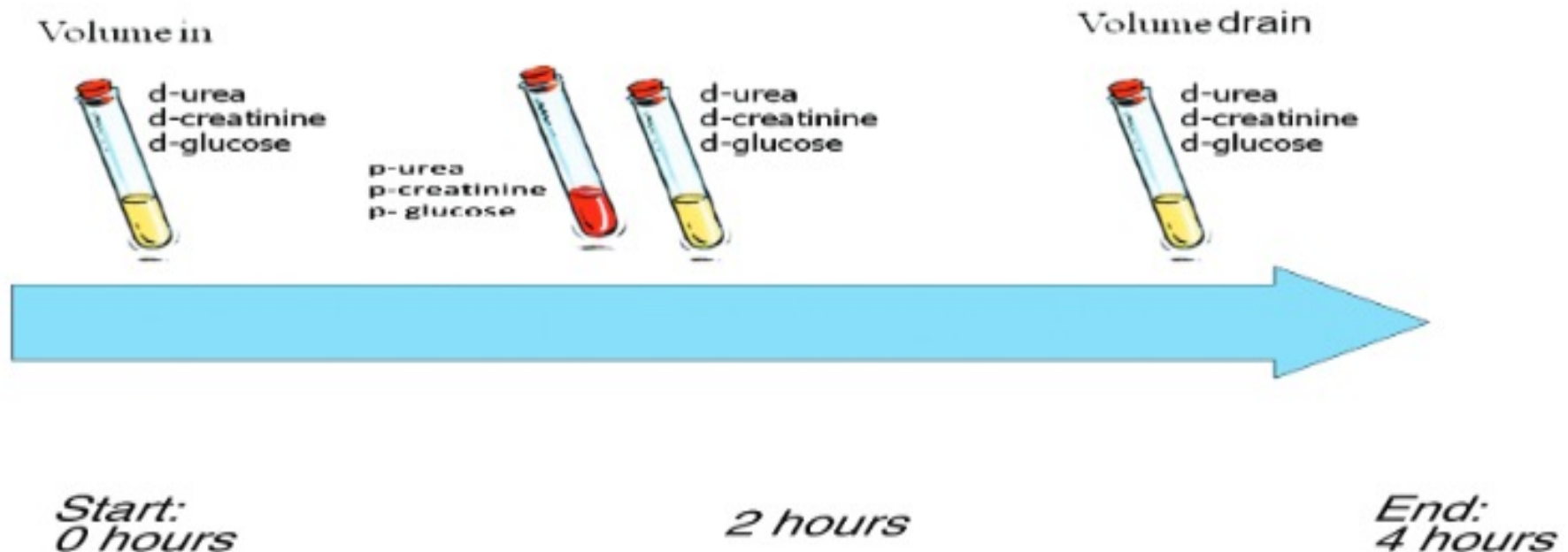
3-5 exchanges/day with
dwell time: 4 hours **AND**

1 nocturnal exchange with
dwell time: ~9 hours

Consider icodextrin in long dwell if additional ultrafiltration is needed

Peritoneal Equilibration Test (PET)

- Test of peritoneal membrane transport
- 4 hour dwell, 1,100 mL/m² BSA, 2.5% Dextrose
- “Short” PET – 2 hours

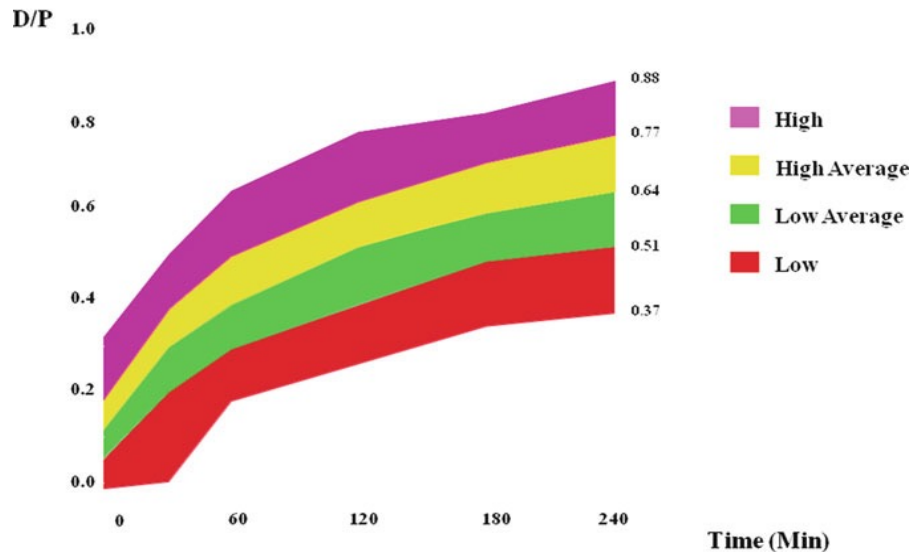


PET: *Transporter Type*

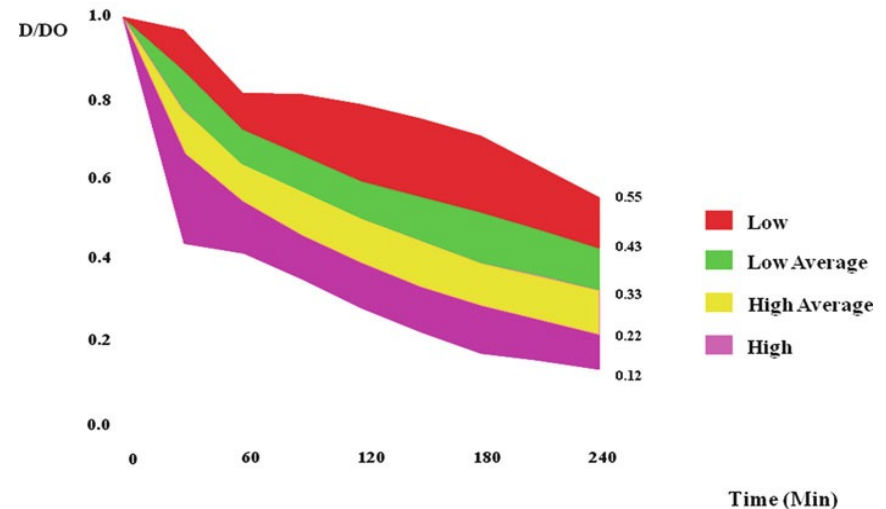
Category of peritoneal transport	D/P urea ^a	D/P creatinine ^a	D/D0 glucose ^a
High	0.91–0.94	0.77–0.88	0.12–0.21
High average	0.82–0.90	0.64–0.76	0.22–0.32
Low average	0.74–0.81	0.51–0.63	0.33–0.42
Low	0.54–0.73	0.37–0.50	0.43–0.55

^aAt a 4 h dwell of an exchange performed with 1,100 ml/m² BSA of a 2.5% dextrose solution

Creatinine



Glucose



PET: *Transporter Type*

Transporter Type	Characteristics	Prescription
High	<ul style="list-style-type: none">-Highly permeable membrane-Rapid solute clearance-Loss of osmotic gradient quickly (poor UF)-Higher protein loss (lower albumin)	<ul style="list-style-type: none">-Shorter dwell times-NIPD, or APD with icodextrin daytime fill
High Average	<ul style="list-style-type: none">-Efficient membrane-Good solute clearance-Good UF	<ul style="list-style-type: none">-Any dialysis regimen
Low Average	<ul style="list-style-type: none">-Less efficient membrane-Slower solute clearance-Good UF	<ul style="list-style-type: none">-Any dialysis regimen, but with fewer cycles
Low	<ul style="list-style-type: none">-Low membrane permeability-Slow solute clearance-Very good UF-Lower protein loss (higher albumin)	<ul style="list-style-type: none">-Larger fill volumes-Longer duration of dwell with less cycles-CAPD or CCPD

PD Rx: Modeled Approach

Kinetic Modeling Software Based Programs

- PD-Adequest 2.0 (Baxter)
 - Validated in children*
- Patient Online (Fresenius)

PD Rx: Adjustment

Inadequate Clearance

- Introduce daytime dwell
- Increase fill volume
- Lengthen dwell time
- Increase number of exchanges
- Increase solution tonicity

Inadequate Ultrafiltration

- Increase solution tonicity
- Icodextrin
- Shorten dwell time

PD Adequacy

Delivered dose of dialysis is “adequate”:

- Optimal growth
- Blood pressure control
- Optimal nutritional status
- Avoidance of hypovolemia and sodium depletion
- Adequate psychomotor development

ISPD 2020 Dialysis Practice Recommendations

- Well-being of the person on dialysis is related to many different factors and not just removal of specific toxins
- High-Quality Goal-Directed PD
 - Maintain quality of life for PD patient
 - Minimize symptoms and treatment burden
 - Ensure high quality care

ISPD 2020 Dialysis Practice Recommendations

Shared decision making

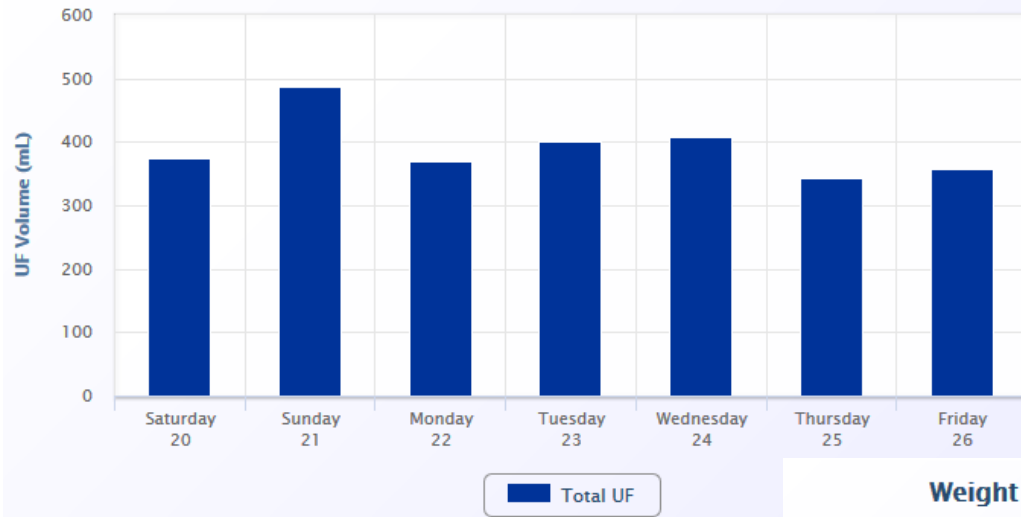
Assessments:

- Patient reported outcome measures
- Fluid status
- Anemia
- Nutrition status
- Bone mineral management
- Removal of toxins

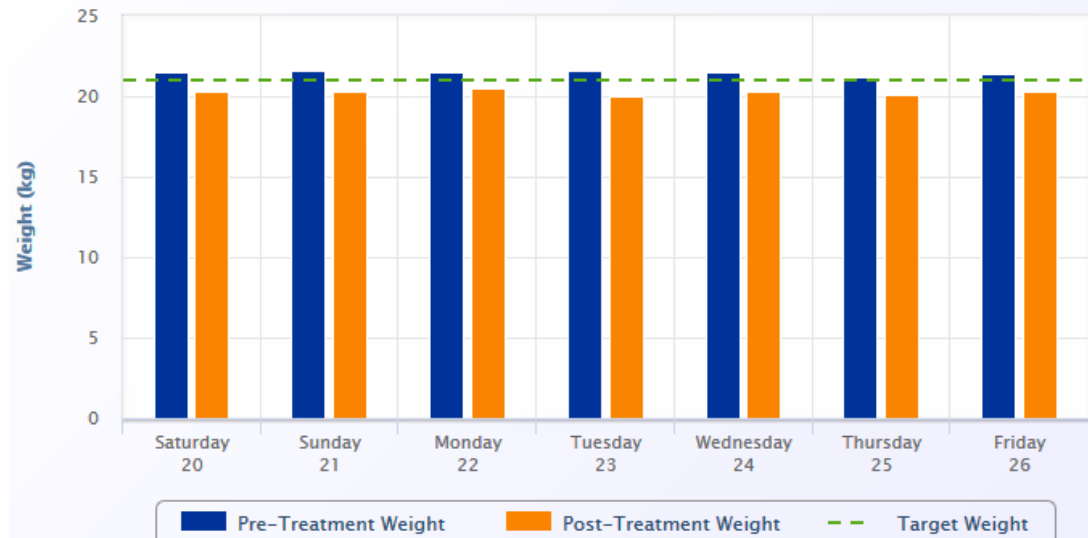
Preservation of residual kidney function

PD Rx: Assessment

Total UF



Weight

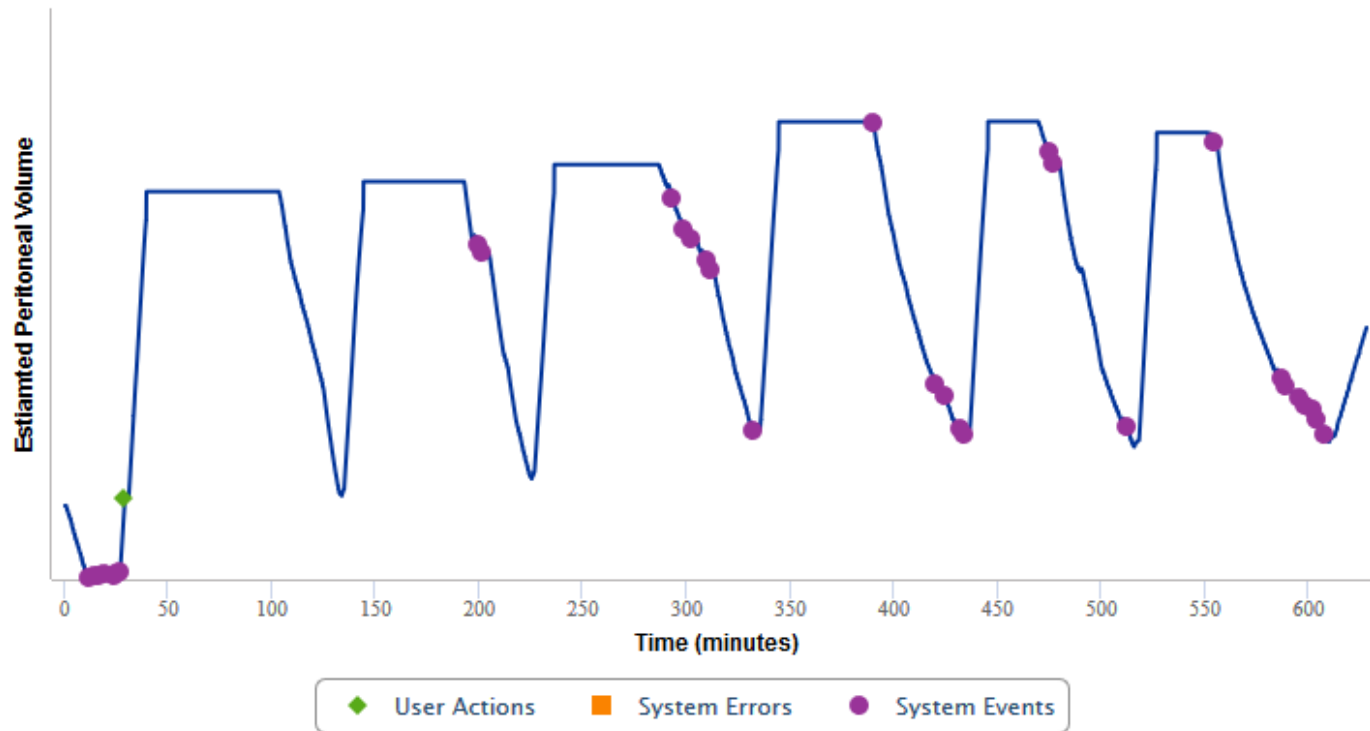


PD Rx: Assessment

Cycle Profiles



For the Events that happen close together, use the zoom feature. It's recommended to refer to Events table above for specific details on time and events during treatment.

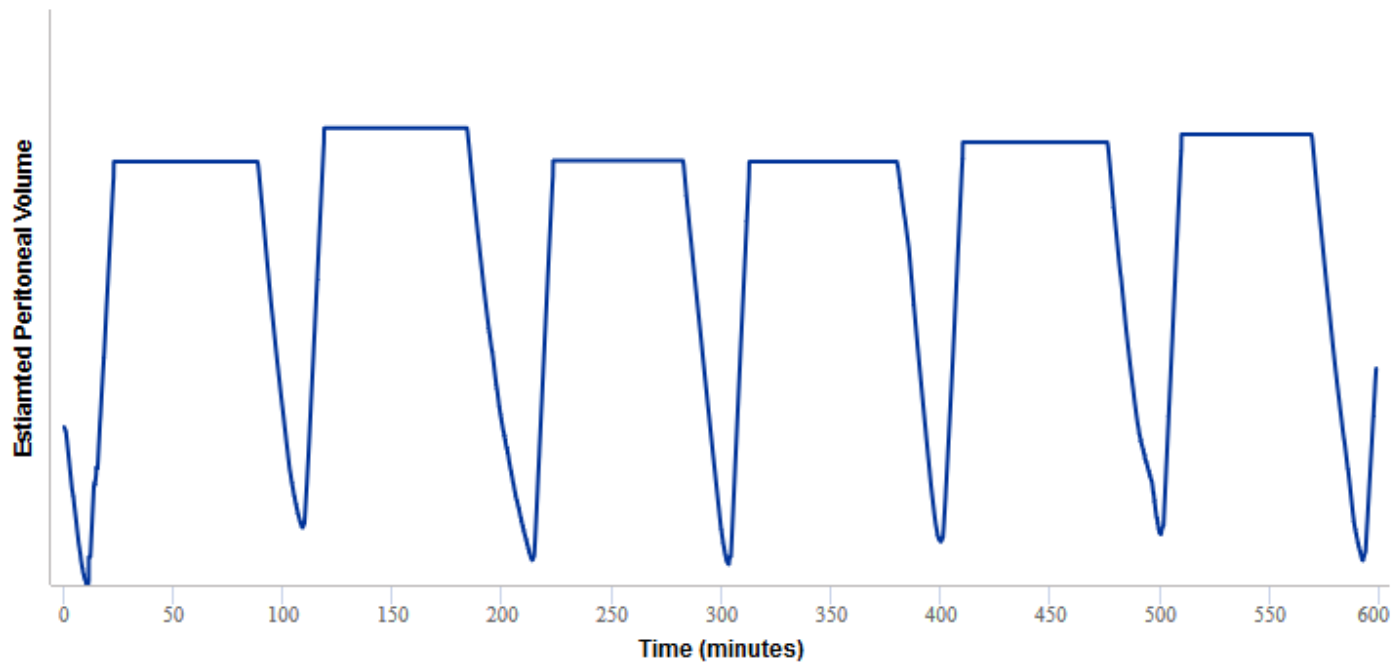


PD Rx: Assessment

Cycle Profiles



For the Events that happen close together, use the zoom feature. It's recommended to refer to Events table above for specific details on time and events during treatment.



User Actions



System Errors



System Events

Adequacy: Measures of Clearance

- Solute Clearance Measures:
 - Weekly Kt/V_{urea}
 - Weekly Creatinine Clearance
- Guidelines and consensus statements historically have favored use of Kt/V_{urea} as the 'standard' measure to follow
 - No high-quality evidence regarding need or benefit associated with achievement of specific target*

*International Society for Peritoneal Dialysis practice recommendations: Prescribing high-quality goal-directed peritoneal dialysis. *Perit Dial Int* 2020; 40(3)244-253.

Kt/V_{urea}

- “K” is representative of CLEARANCE of UREA
 - Kd = clearance of dialysis delivered
 - Kr = clearance of ‘residual’ renal function
- “t” is the time over which dialysis is delivered
 - In PD calculations, “t” is normally considered 24 hours/day (calculation is based on full day of dialysate/urine output, then scaled to 1 week)
- “V”_{urea} is the volume of distribution for Urea in the patient, which is the patient’s TBW

Total Kt/V_{urea} = dialysis + renal clearance

Weekly Peritoneal Dialysis Kt/V

$$\frac{24 \text{ Hr D/P urea} \times 24\text{-hr drained volume} \times 7}{V}$$

Weekly Renal Kt/V

$$\frac{\text{mL/min Urea clearance} \times 1440 \text{ min/day} \times 7}{1000 \text{ mL} \times V}$$

Daily Renal Urea Clearance

$$\frac{\text{Volume of 24-hr urine in mL} \times \text{Urine Urea Nitrogen Conc.}}{1440 \text{ min/day} \times \text{BUN Concentration}}$$

Total Body Water Calculation

Males: $TBW = 0.010$

$$\begin{aligned} & \bullet (\text{height} \cdot \text{weight})^{0.68} \\ & \quad - 0.37 \cdot \text{weight} \end{aligned}$$

Females: $TBW = 0.14$

$$\begin{aligned} & \bullet (\text{height} \cdot \text{weight})^{0.64} \\ & \quad - 0.35 \cdot \text{weight} \end{aligned}$$

Table 17. Male Total Body Water (L) Nomograms

Weight (kg)	Height (cm)																
	50	54	58	62	66	70	74	78	82	86	90	94	98	102	106	110	114
2	1.6	1.7	1.8	1.9													
3	1.9	2.1	2.2	2.4													
4	2.2	2.4	2.6	2.8	3.0												
5	2.4	2.7	2.9	3.1	3.3												
6	2.6	2.9	3.1	3.4	3.6	3.9	4.1										
7	2.8	3.1	3.4	3.6	3.9	4.2	4.4	4.7	4.9								
8	2.9	3.2	3.5	3.9	4.1	4.4	4.7	5.0	5.3	5.5	5.8						
9				4.0	4.4	4.7	5.0	5.3	5.6	5.9	6.2	6.5	6.7				
10				4.2	4.6	4.9	5.2	5.6	5.9	6.2	6.5	6.8	7.1	7.4	7.7		
11				4.4	4.8	5.1	5.5	5.8	6.2	6.5	6.8	7.1	7.5	7.8	8.1	8.4	8.7
12				4.5	4.9	5.3	5.7	6.0	6.4	6.8	7.1	7.5	7.8	8.1	8.5	8.8	9.1
13								6.3	6.6	7.0	7.4	7.8	8.1	8.5	8.8	9.2	9.5
14								6.5	6.9	7.3	7.7	8.0	8.4	8.8	9.2	9.5	9.9
15								6.7	7.1	7.5	7.9	8.3	8.7	9.1	9.5	9.9	10.2
16								6.8	7.3	7.7	8.1	8.6	9.0	9.4	9.8	10.2	10.6
17											8.4	8.8	9.2	9.7	10.1	10.5	10.9
18											8.6	9.0	9.5	9.9	10.4	10.8	11.2
19											8.8	9.3	9.7	10.2	10.6	11.1	11.5
20											9.0	9.4	9.9	10.4	10.9	11.3	11.8

Table 17 (cont'd). Male Total Body Water (L) Nomograms

Weight (kg)	Height (cm)																					
	106	110	114	118	122	126	130	134	138	142	146	150	154	158	162	166	170	174	178	182	186	190
20	10.9	11.3	11.8	12.3	12.7	13.2	13.6	14.0	14.5	14.9	15.3	15.7										
22	11.4	11.9	12.4	12.8	13.3	13.8	14.3	14.7	15.2	15.7	16.1	16.6										
24	11.8	12.3	12.9	13.4	13.9	14.4	14.9	15.4	15.9	16.4	16.8	17.3	17.8	18.3	18.7							
26	12.2	12.8	13.3	13.9	14.4	15.0	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5							
28	12.6	13.2	13.8	14.4	14.9	15.5	16.0	16.6	17.1	17.7	18.2	18.7	19.3	19.8	20.3	20.8	21.3					
30	13.0	13.6	14.2	14.8	15.4	16.0	16.6	17.1	17.7	18.3	18.8	19.4	19.9	20.5	21.0	21.6	22.1					
32	13.3	14.0	14.6	15.2	15.8	16.5	17.1	17.7	18.3	18.9	19.4	20.0	20.6	21.2	21.7	22.3	22.9	23.4	24.0			
34	13.6	14.3	15.0	15.6	16.3	16.9	17.5	18.2	18.8	19.4	20.0	20.6	21.2	21.8	22.4	23.0	23.6	24.2	24.7			
36	13.9	14.6	15.3	16.0	16.7	17.3	18.0	18.7	19.3	19.9	20.6	21.2	21.8	22.4	23.1	23.7	24.3	24.9	25.5	26.1	26.6	
38	14.2	14.9	15.7	16.4	17.1	17.8	18.4	19.1	19.8	20.4	21.1	21.8	22.4	23.0	23.7	24.3	24.9	25.6	26.2	26.8	27.4	
40			18.0	18.7	19.4	18.1	18.8	19.6	20.2	20.9	21.6	22.3	23.0	23.6	24.3	24.9	25.6	26.2	26.9	27.5	28.1	28.8
42			18.3	19.0	19.7	18.5	19.2	20.0	20.7	21.4	22.1	22.8	23.5	24.2	24.9	25.5	26.2	26.9	27.5	28.2	28.8	29.5
44			18.5	19.3	19.9	18.9	19.6	20.4	21.1	21.8	22.6	23.3	24.0	24.7	25.4	26.1	26.8	27.5	28.2	28.8	29.5	30.2
46			18.8	19.6	20.2	19.2	20.0	20.8	21.5	22.3	23.0	23.8	24.5	25.2	26.0	26.7	27.4	28.1	28.8	29.5	30.2	30.9
48			19.1	19.9	20.5	19.5	20.3	21.1	21.9	22.7	23.5	24.2	25.0	25.7	26.5	27.2	27.9	28.7	29.4	30.1	30.8	31.5
50			19.3	19.9	20.5	19.8	20.7	21.5	22.3	23.1	23.9	24.7	25.4	26.2	27.0	27.7	28.5	29.2	30.0	30.7	31.5	32.2
52						20.1	21.0	21.8	22.5	23.3	24.3	25.1	25.9	26.7	27.5	28.2	29.0	29.8	30.6	31.3	32.1	32.8
54						20.4	21.3	22.1	22.9	23.8	24.7	25.5	26.3	27.1	27.9	28.7	29.5	30.3	31.1	31.9	32.7	33.4
56						20.7	21.6	22.5	23.3	24.2	25.0	25.9	26.7	27.6	28.4	29.2	30.0	30.8	31.7	32.4	33.2	34.0
58						20.9	21.8	22.8	23.7	24.5	25.4	26.3	27.1	28.0	28.8	29.7	30.5	31.4	32.2	33.0	33.8	34.6
60						21.2	22.1	23.1	24.0	24.9	25.8	26.7	27.5	28.4	29.3	30.1	31.0	31.8	32.7	33.5	34.4	35.2
62						21.4	22.4	23.3	24.3	25.2	26.1	27.0	27.9	28.8	29.7	30.6	31.5	32.3	33.2	34.0	34.9	35.7
64								21.7	22.6	23.6	24.5	25.5	26.4	27.3	28.2	29.1	30.0	30.9	31.8	32.7	33.6	34.5
66									24.8	25.8	26.8	27.7	28.6	29.6	30.5	31.4	32.3	33.2	34.1	35.0	35.9	36.8
68									25.1	26.1	27.1	28.0	29.0	30.0	30.9	31.8	32.8	33.7	34.6	35.5	36.4	37.3
70									25.4	26.4	27.4	28.4	29.3	30.3	31.3	32.2	33.2	34.1	35.1	36.0	36.9	37.8
72									25.5	26.6	27.7	28.7	29.7	30.7	31.6	32.6	33.6	34.5	35.5	36.4	37.4	38.3
74									25.9	26.8	27.9	28.9	30.0	31.0	32.0	33.0	34.0	34.9	35.9	36.8	37.8	38.8
76									26.1	27.2	28.2	29.3	30.3	31.3	32.3	33.3	34.4	35.3	36.3	37.3	38.3	39.3
78									26.3	27.4	28.5	29.5	30.6	31.5	32.7	33.7	34.7	35.7	36.7	37.7	38.7	39.7
80									26.5	27.6	28.7	29.8	30.9	31.9	33.0	34.1	35.1	36.1	37.1	38.2	39.2	40.2

Table 18. Female Total Body Water (L) Nomograms

		Height (cm)																
		50	54	58	62	66	70	74	78	82	86	90	94	98	102	106	110	114
Weight (kg)	2	2.0	2.1	2.2	2.4													
	3	2.4	2.6	2.8	2.9													
	4	2.8	3.0	3.2	3.4	3.6												
	5	3.1	3.3	3.5	3.8	4.0												
	6	3.3	3.6	3.8	4.1	4.3	4.6	4.8										
	7	3.5	3.8	4.1	4.4	4.8	4.9	5.2	5.5	5.7								
	8	3.7	4.0	4.3	4.6	4.9	5.2	5.5	5.8	6.1	6.4	6.6						
	9				4.9	5.2	5.5	5.8	6.1	6.4	6.7	7.0	7.3	7.6				
	10				5.1	5.4	5.8	6.1	6.4	6.8	7.1	7.4	7.7	8.0	8.3	8.6		
	11				5.3	5.6	6.0	6.4	6.7	7.1	7.4	7.7	8.1	8.4	8.7	9.0	9.3	9.6
	12				5.4	5.8	6.2	6.6	7.0	7.3	7.7	8.0	8.4	8.7	9.1	9.4	9.7	10.0
	13								7.2	7.6	8.0	8.3	8.7	9.1	9.4	9.8	10.1	10.4
	14								7.4	7.8	8.2	8.6	9.0	9.4	9.7	10.1	10.5	10.8
	15								7.6	8.0	8.5	8.9	9.3	9.7	10.0	10.4	10.8	11.2
	16								7.8	8.3	8.7	9.1	9.5	9.9	10.3	10.7	11.1	11.5
	17											9.3	9.8	10.2	10.6	11.0	11.4	11.8
	18											9.6	10.0	10.5	10.9	11.3	11.7	12.2
	19											9.8	10.2	10.7	11.1	11.6	12.0	12.5
	20											10.0	10.4	10.9	11.4	11.8	12.3	12.7

Table 18 (cont'd). Female Total Body Water (L) Nomograms

		Height (cm)																						
		106	110	114	118	122	126	130	134	138	142	146	150	154	158	162	166	170	174	178	182	186	190	
Weight (kg)	20	11.8	12.3	12.7	13.2	13.6	14.0	14.5	14.9	15.3	15.7	16.1	16.5											
	22	12.3	12.8	13.3	13.7	14.2	14.7	15.1	15.6	16.0	16.4	16.9	17.3											
	24	12.8	13.3	13.8	14.3	14.8	15.2	15.7	16.2	16.7	17.1	17.6	18.0	18.5	18.9	19.4								
	26	13.2	13.7	14.2	14.8	15.3	15.8	16.3	16.8	17.3	17.8	18.3	18.7	19.2	19.7	20.1								
	28	13.6	14.1	14.7	15.2	15.8	16.3	16.8	17.3	17.9	18.4	18.9	19.4	19.9	20.4	20.9	21.3	21.8						
	30	13.9	14.5	15.1	15.7	16.2	16.8	17.3	17.9	18.4	18.9	19.5	20.0	20.5	21.0	21.5	22.0	22.5						
	32	14.3	14.9	15.5	16.1	16.6	17.2	17.8	18.4	18.9	19.5	20.0	20.6	21.1	21.7	22.2	22.7	23.2	23.7	24.3				
	34	14.6	15.2	15.8	16.4	17.0	17.7	18.2	18.8	19.4	20.0	20.6	21.1	21.7	22.3	22.8	23.4	23.9	24.4	25.0				
	36	14.8	15.5	16.2	16.8	17.4	18.1	18.7	19.3	19.9	20.5	21.1	21.7	22.3	22.8	23.4	24.0	24.5	25.1	25.6	26.2	26.7	27.4	
	38	15.1	15.8	16.5	17.1	17.8	18.4	19.1	19.7	20.3	21.0	21.6	22.2	22.8	23.4	24.0	24.6	25.1	25.7	26.3	26.9	27.4		
	40			16.8	17.4	18.1	18.8	19.5	20.1	20.7	21.4	22.0	22.7	23.3	23.9	24.5	25.1	25.7	26.3	26.9	27.5	28.1	28.6	
	42			17.0	17.7	18.4	19.1	19.8	20.5	21.1	21.8	22.5	23.1	23.8	24.4	25.0	25.7	26.3	26.9	27.5	28.1	28.7	29.3	
	44			17.3	18.0	18.7	19.5	20.2	20.9	21.5	22.2	22.9	23.6	24.2	24.9	25.5	26.2	26.8	27.4	28.1	28.7	29.3	29.9	
	46			17.5	18.3	19.0	19.8	20.5	21.2	21.9	22.6	23.3	24.0	24.7	25.3	26.0	26.7	27.3	28.0	28.6	29.3	29.9	30.5	
	48			17.8	18.5	19.3	20.0	20.8	21.5	22.3	23.0	23.7	24.4	25.1	25.8	26.5	27.2	27.8	28.5	29.2	29.8	30.5	31.1	
	50			18.0	18.8	19.6	20.3	21.1	21.8	22.6	23.3	24.1	24.8	25.5	26.2	26.9	27.6	28.3	29.0	29.7	30.4	31.0	31.7	
	52						20.6	21.4	22.1	22.9	23.7	24.4	25.2	25.9	26.6	27.4	28.1	28.8	29.5	30.2	30.9	31.6	32.2	
	54						20.8	21.6	22.4	23.2	24.0	24.8	25.5	26.3	27.0	27.8	28.5	29.2	29.9	30.7	31.4	32.1	32.8	
	56						21.1	21.9	22.7	23.5	24.3	25.1	25.9	26.6	27.4	28.2	28.9	29.7	30.4	31.1	31.9	32.6	33.3	
	58						21.3	22.1	23.0	23.8	24.6	25.4	26.2	27.0	27.8	28.5	29.3	30.1	30.8	31.6	32.3	33.1	33.8	
	60						21.5	22.4	23.2	24.1	24.9	25.7	26.5	27.3	28.1	28.9	29.7	30.5	31.3	32.0	32.8	33.5	34.3	
	62						21.7	22.6	23.4	24.3	25.2	26.0	26.8	27.7	28.5	29.3	30.1	30.9	31.7	32.4	33.2	34.0	34.8	
	64						21.9	22.8	23.7	24.6	25.4	26.3	27.1	28.0	28.8	29.6	30.4	31.3	32.1	32.9	33.6	34.4	35.2	
	66									24.8	25.7	26.5	27.4	28.3	29.1	30.0	30.8	31.6	32.4	33.2	34.1	34.9	35.7	
	68									25.0	25.9	26.8	27.7	28.6	29.4	30.3	31.1	32.0	32.8	33.6	34.5	35.3	36.1	
	70									25.2	26.1	27.0	27.9	28.8	29.7	30.6	31.5	32.3	33.2	34.0	34.9	35.7	36.5	
	72									25.4	26.4	27.3	28.2	29.1	30.0	30.9	31.8	32.7	33.5	34.4	35.2	36.1	36.9	
	74									25.6	26.6	27.5	28.4	29.4	30.3	31.2	32.1	33.0	33.9	34.7	35.6	36.5	37.3	
	76									25.8	26.8	27.7	28.7	29.6	30.6	31.5	32.4	33.3	34.2	35.1	36.0	36.8	37.7	
	78									26.0	27.0	27.9	28.9	29.9	30.8	31.7	32.7	33.6	34.5	35.4	36.3	37.2	38.1	
	80									26.2	27.2	28.1	29.1	30.1	31.1	32.0	33.0	33.9	34.8	35.7	36.7	37.6	38.5	

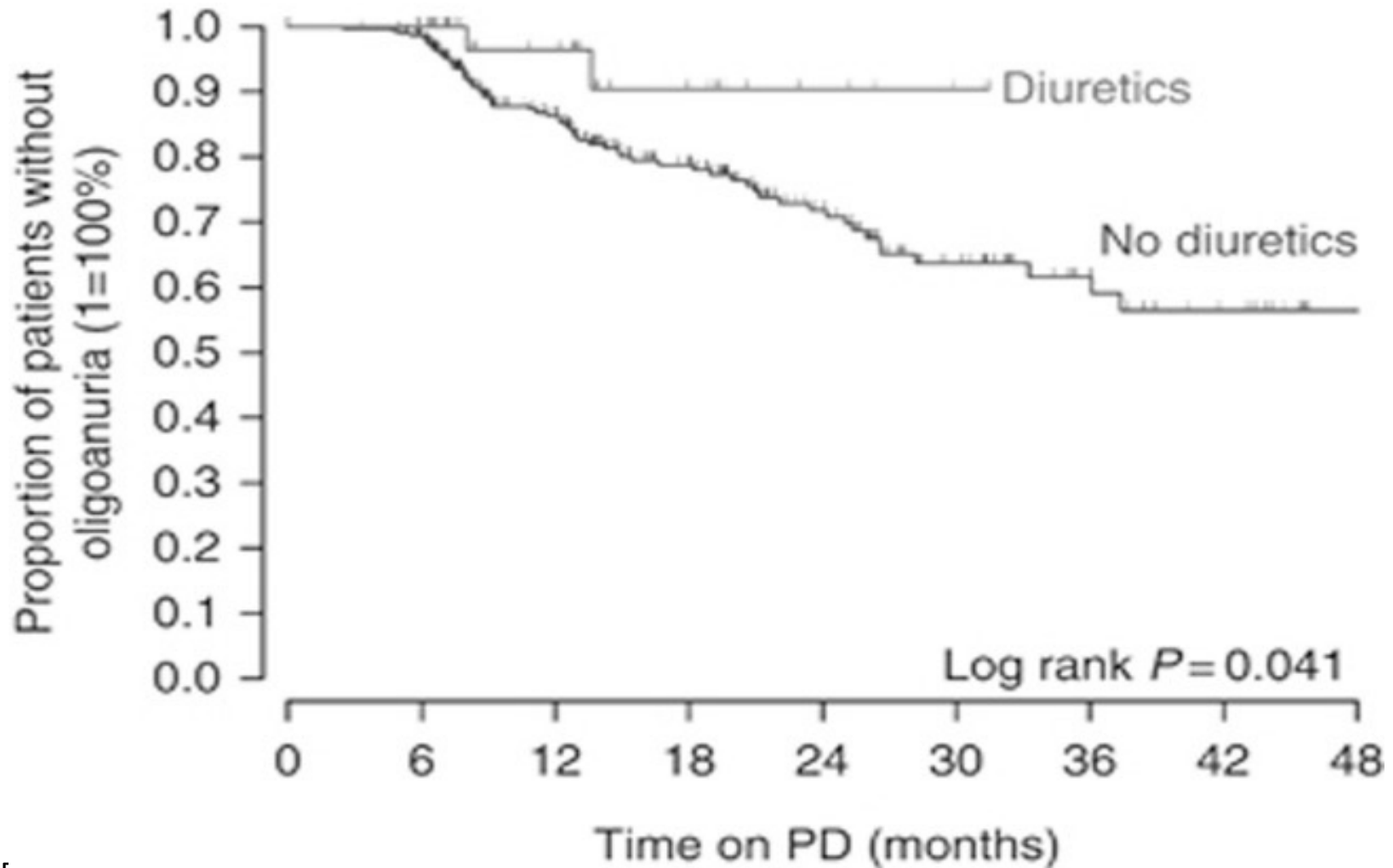
Solute Clearance

- PD prescription should be adjusted with goal of achieving a normal serum phosphate level
- Total minimum weekly $Kt/V_{\text{urea}} = 1.7$
 - *If less than 1.7 and otherwise doing well, should not have PD prescription increased for sole purpose of meeting target*

Residual Kidney Function

- Should be measured when UOP > 100 mL/day
- Defined as urine $Kt/V_{\text{urea}} > 0.1/\text{week}$
- 24 hour urine collection for urine volume and solute clearance determinations should be obtained at a minimum of every 3 months

Residual Kidney Function



- NKF KDOQI Guidelines 2006
- Prescribing peritoneal dialysis for high-quality care in children.

Management

- The pediatric patient's clinical status should be reviewed at least monthly, and delivery of prescribed solute clearance should render the patient free of signs and symptoms of uremia
- Measure Kt/V one month after starting dialysis, when clinically needed and *at least* every 6 months
- PD effluent UF should be reviewed every month

Summary

- PD prescription must be individualized and optimized, and continually re-assessed
 - *“should be designed to meet medical, mental health, social and financial needs of the individual child and family”*
- Recommended minimal “delivered” dose of solute clearance should be a Kt/V_{urea} 1.7/week
- High Quality Goal Directed Care
 - BP control, fluid management, growth, nutrition, bone disease, development, and quality of life

Useful Resources

- Optimal Care of the Infant, Child and Adolescent on Dialysis: 2014 Update. *Am J Kidney Dis* 2014; 64(1):128-142
- Care of the Pediatric Patient on Chronic Dialysis. *Adv Chronic Kidney Dis* 2017; 24(6): 388-397
- Pediatric Dialysis, 3rd Edition. Warady, Schaefer, Alexander.
 - Chapter 13 Technical Aspects of Prescription of Peritoneal Dialysis in Children, p 193-228
- Handbook of Dialysis, 5th Edition. Daugirdas, Blake and Ing.
 - Chapter 25 Adequacy of Peritoneal Dialysis p464-482
 - Chapter 26 Volume Status and Fluid Overload in Peritoneal Dialysis p483-489
 - Chapter 37 Dialysis in Infants and Children p693-712
- KDOQI Clinical Practice Guidelines and Clinical Practice Recommendations for 2006 Updates. Hemodialysis Adequacy, Peritoneal Dialysis Adequacy and Vascular Access. *Am J Kidney Dis* 2006; 28(suppl 1): S1
- Prescribing peritoneal dialysis for high-quality care in children. *Perit Dial Int* 2020; 40(3)333-340.
- International Society for Peritoneal Dialysis practice recommendations: Prescribing high-quality goal-directed peritoneal dialysis. *Perit Dial Int* 2020; 40(3)244-253.

Peritoneal Dialysis Simulator

www.Openpediatrics.org

Harvard University

A YOUR PROGRESS
Prescription
Fill Volume
Initial fill volumes are typically 5-10 mL/kg, with gradual increases up to 20 to 25 mL/kg in smaller infants, and 30-45 mL/kg in older children. In this simulator, start your fill volumes at 5 mL/kg and increase your fill volumes to promote increased clearance as needed.
The volume of each fill limits the amount of clearance that one can achieve, as molecules can only move down a concentration gradient. Thus, the volume of dialysate instilled in a 24-hour period is the total maximum clearance achieved, assuming 100% efficacy.
With shorter cycles, one never reaches equilibrium between blood and dialysate, and thus the clearance may be less than the volume of dialysate.

B YOUR PROGRESS
Tactic 6
Examine and evaluate your patient by completing the actions below:
1. Assess the Patient
2. Monitor Vital Signs
3. Check Fluid Balance
4. Check Effluent
5. Check Lab Results
Results - Day 1
Cycles: 4
PD Input: 200 mL
PD Output: 220 mL
PD Balance: -20 mL
Effluent
Patient Info
DIAGNOSIS: None
NAME: Ryan WEIGHT: 2.7 kg
AGE: 2 weeks LOCATION: NICU

C Your Patient Chart
Patient Information
History
Helen, a previously healthy 7-year-old girl, presented to the emergency department with several days of high fevers, pallor and malaise. On presentation, she was tachycardic and hypotensive, and had a prolonged capillary refill time.
Helen was admitted to the hospital where she was resuscitated with multiple boluses of crystalloid fluid. She also received a blood transfusion. Following resuscitation, she became edematous but required vasopressors for low blood pressure, which are now weaning off.
In the last 24 hours, she has only made 5 mL of urine. Diuretics were administered without any improvement in urine output. A peritoneal dialysis catheter was inserted at the bedside in aseptic manner. A KUB shows the catheter in good position.

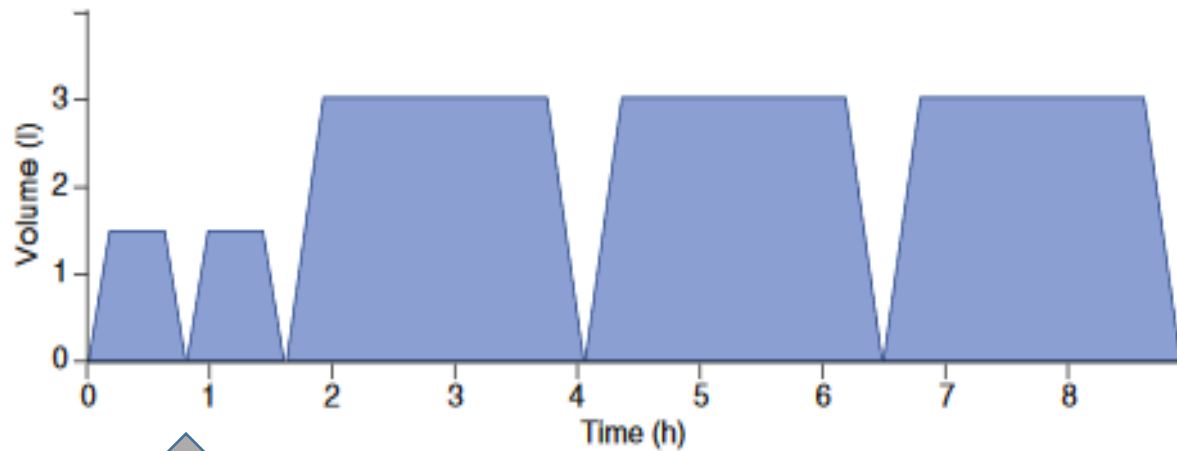
D Congratulations! Your final score is 90%.
To view a scoring breakdown for each task, click View Details below.
Scoring Summary
Task 1: Initial Setup YOUR SCORE: 100%
Task 2: Inadequate Drain Bag Height YOUR SCORE: 100%
Task 3: Poor Ultrafiltration YOUR SCORE: 100%
Task 4: Dehydration YOUR SCORE: 100%
Task 5: Hyponatremia YOUR SCORE: 58%
Task 6: Hypokalemia YOUR SCORE: 100%
Score 95% or better to receive the gold medal!

Screenshots of the various components of the peritoneal dialysis simulator. (A) The knowledge guide. (B) The tactics. (C) The case studies. (D) Learner-controlled feedback.

???Questions???

Thank you!

Adapted APD



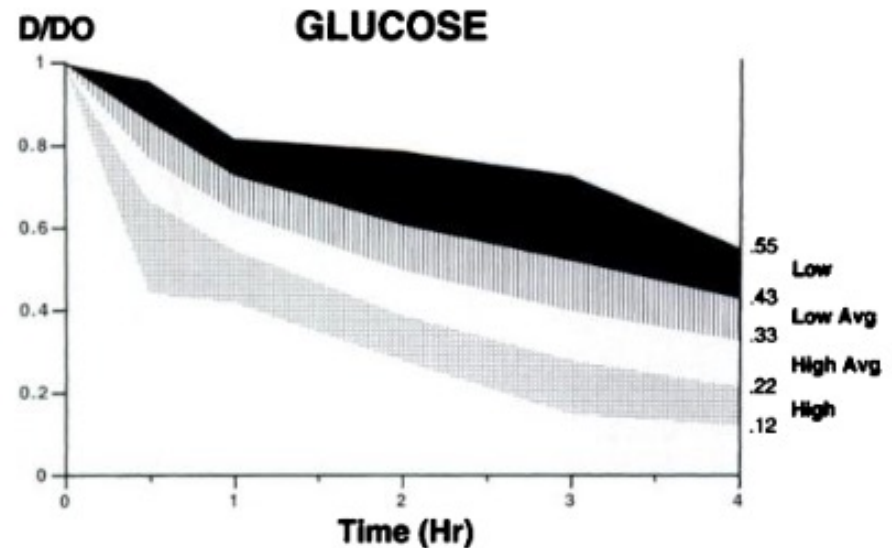
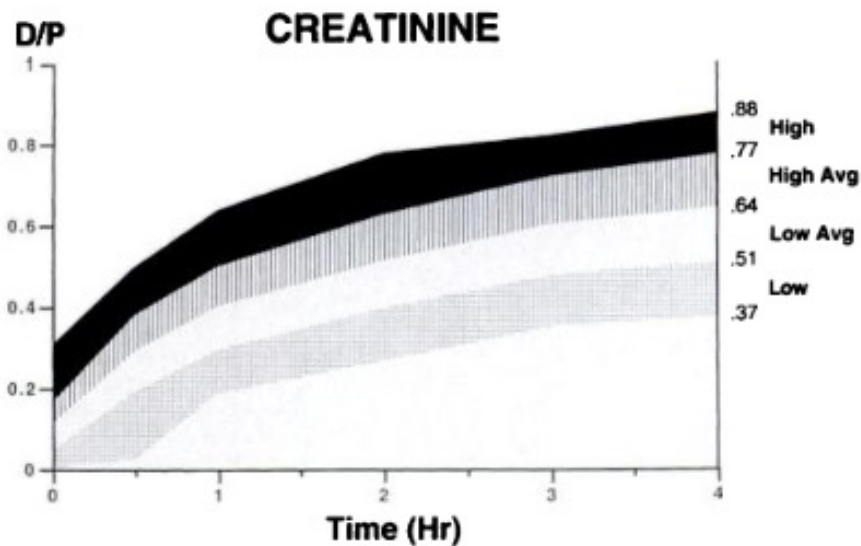
Water and
small molecules

Sodium and
large molecules
(uremic toxins)

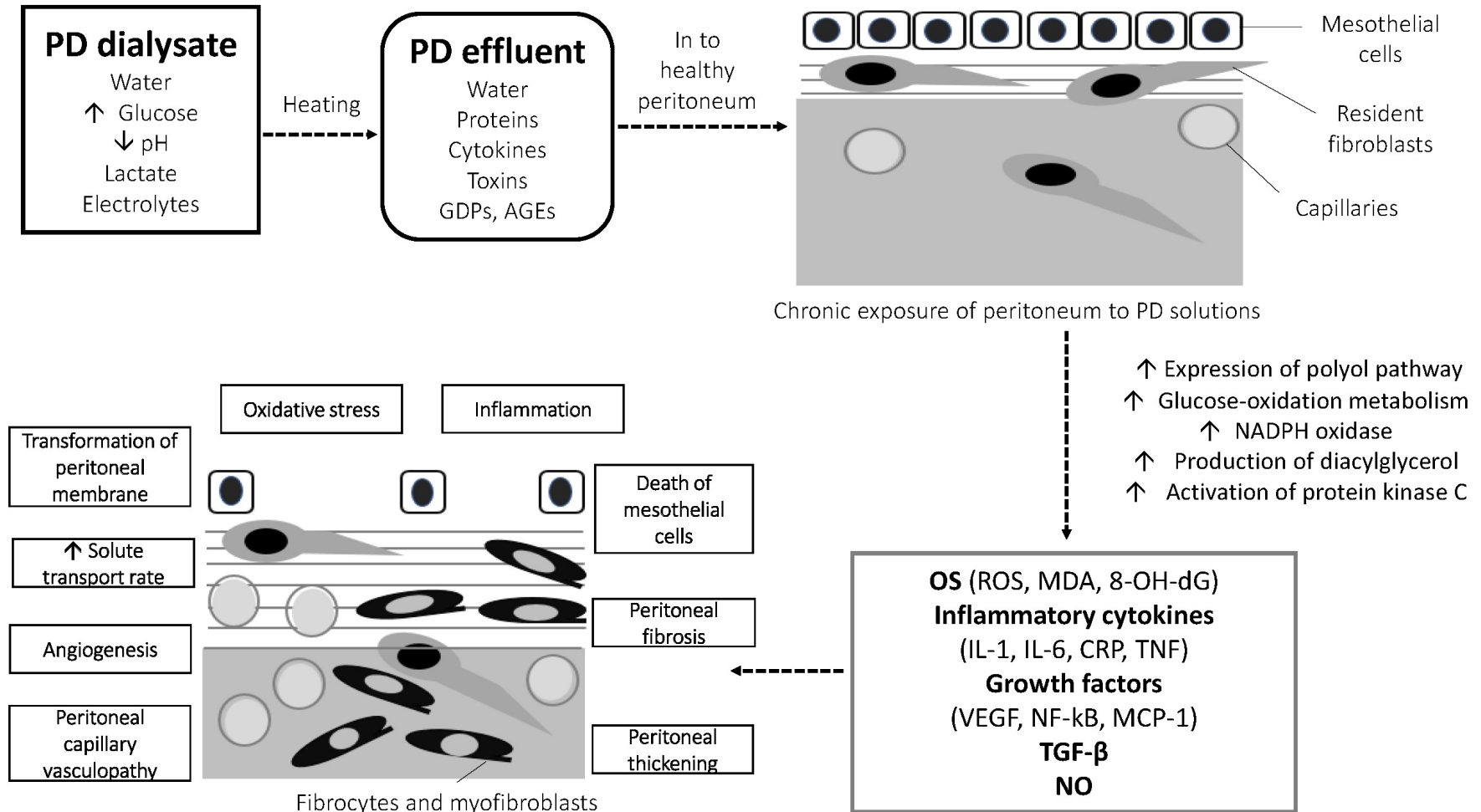
PET: *Transporter Type*

Category of peritoneal transport	D/P urea ^a	D/P creatinine ^a	D/D0 glucose ^a
High	0.91–0.94	0.77–0.88	0.12–0.21
High average	0.82–0.90	0.64–0.76	0.22–0.32
Low average	0.74–0.81	0.51–0.63	0.33–0.42
Low	0.54–0.73	0.37–0.50	0.43–0.55

^aAt a 4 h dwell of an exchange performed with 1,100 ml/m² BSA of a 2.5% dextrose solution



Effects of Conventional Solutions



Ultrafiltration Adequacy: Euvolemia

Causes of Fluid Overload

- Inappropriate solution selection
- Inappropriate prescription for membrane transport status
- Non-adherence to PD or diet
- Peritoneal membrane dysfunction
- Loss of residual kidney function
- Poor blood glucose control

ISPD 2020 Dialysis Practice Recommendations

“PD prescription should be designed to meet medical, mental health, social and financial needs of the individual child and family”