Peritoneal Dialysis Prescription and Adequacy Monitoring

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Disclosures

No financial disclosures relevant to this talk

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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

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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

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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

Prescribing peritoneal dialysis for high-quality care in children.
Perit Dial Int 2020; 40(3)333-340.

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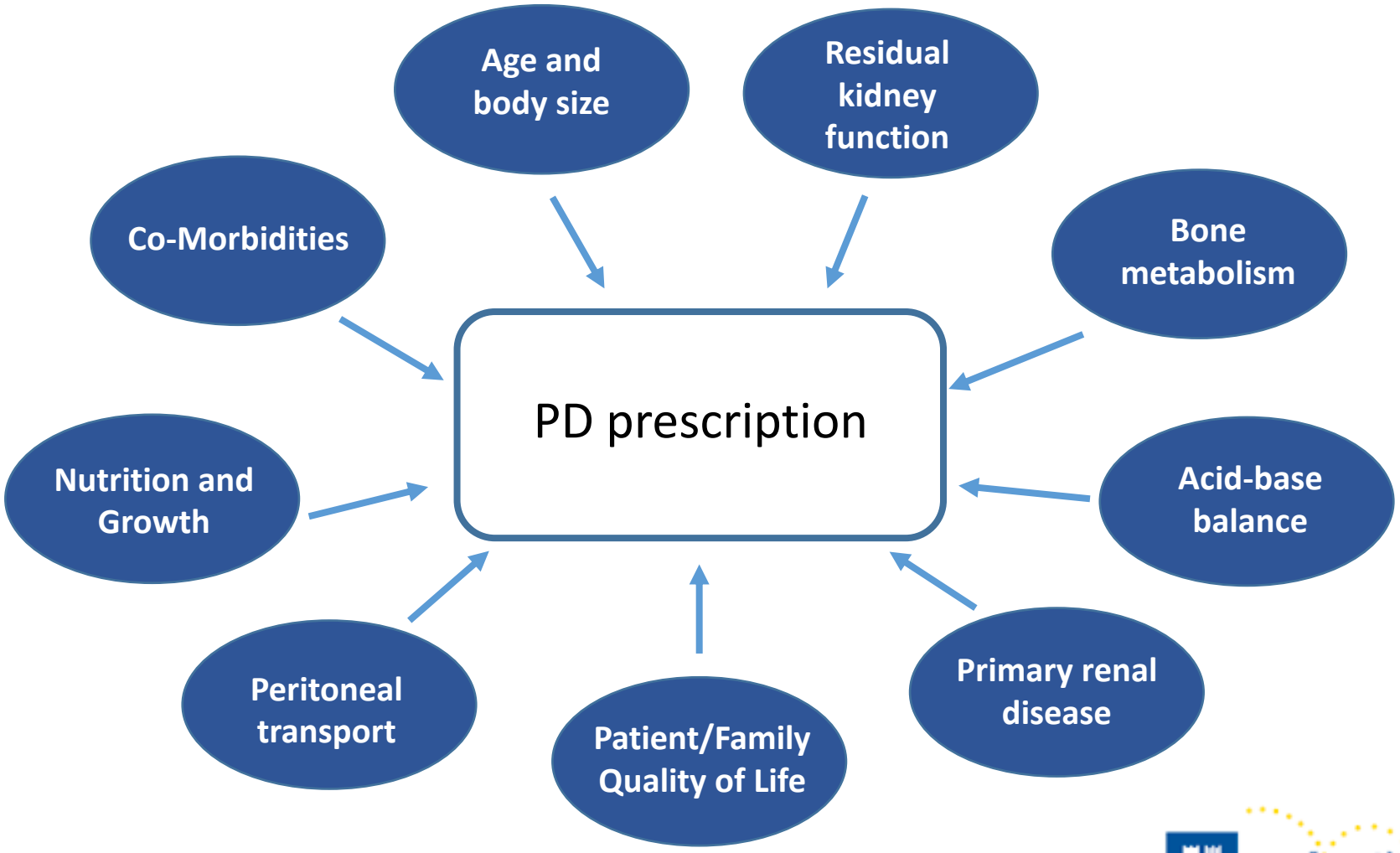
PD Prescription



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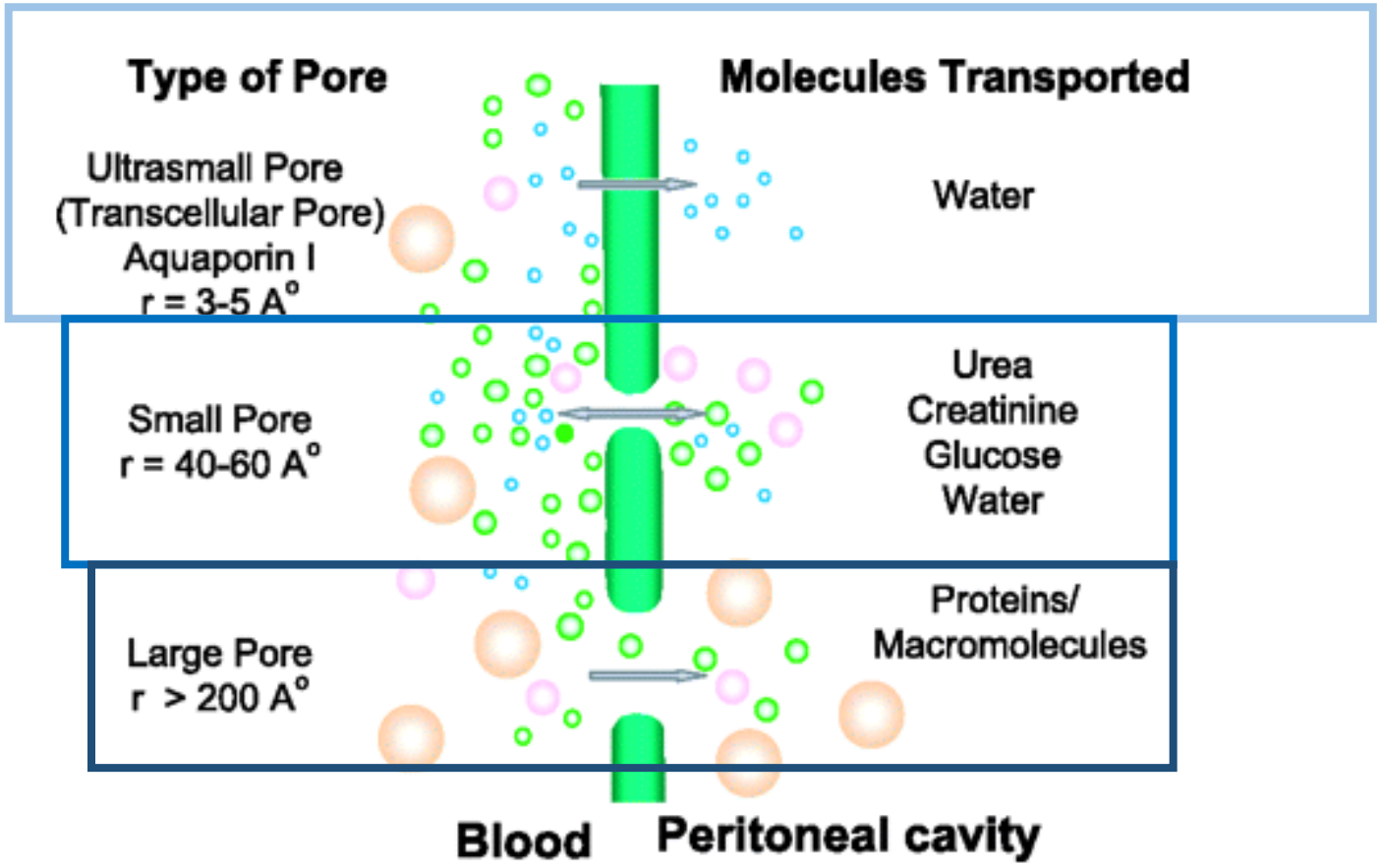
Pediatr Nephrol. 2009 Aug;24(8):1453-64.

Physiology of Peritoneal Membrane



The Journal of the American Board of Family Medicine July 2006, 19 (4) 380-389;

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PD Prescription Components

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

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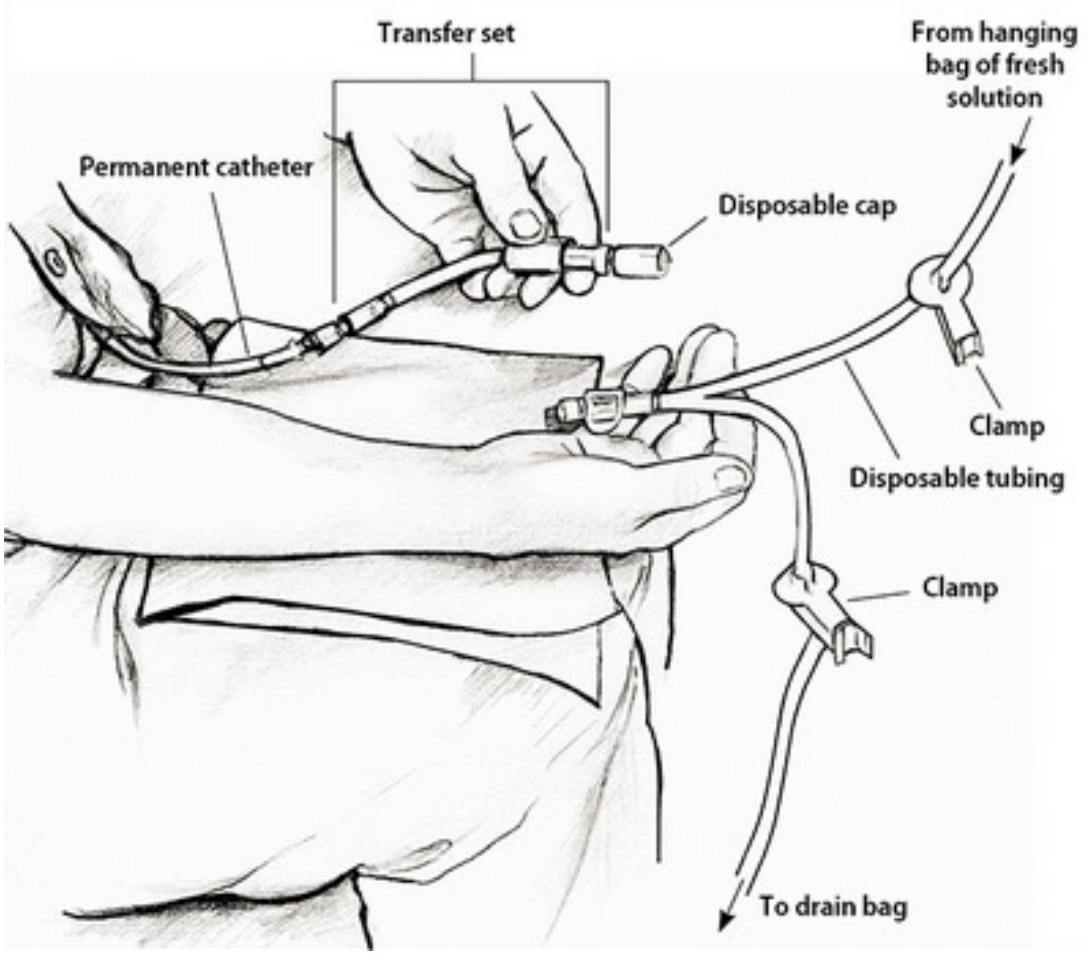
Modality – Continuous Ambulatory Peritoneal Dialysis (CAPD)



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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

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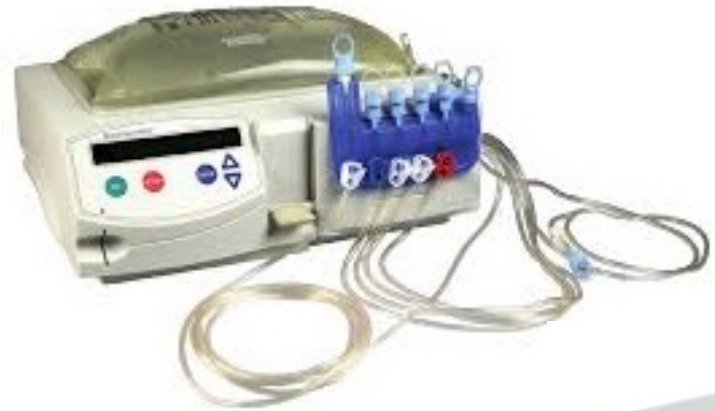
Modality – Automated Peritoneal Dialysis (APD)



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

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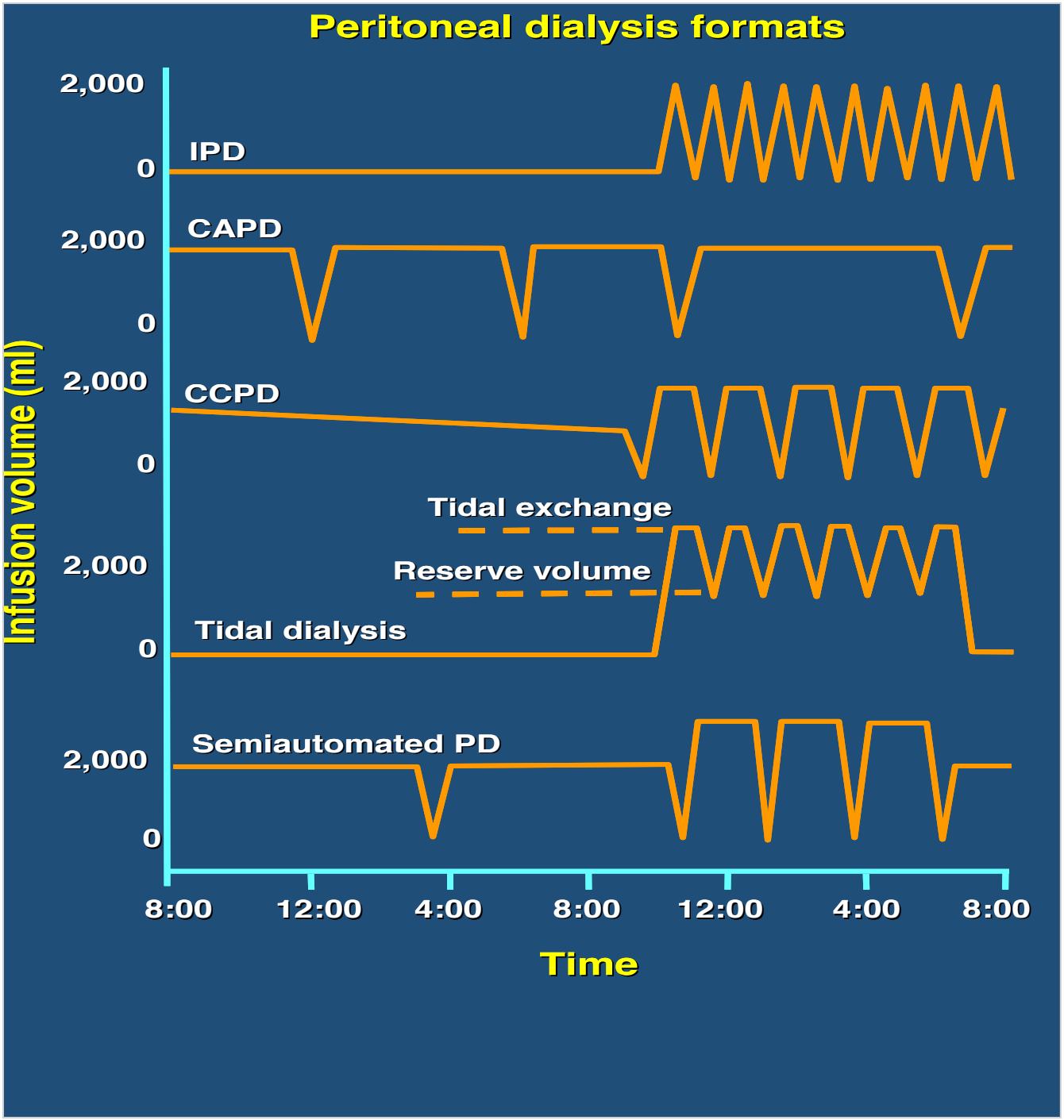
Peritoneal dialysis formats
Infusion volume (ml)
2,000
0
IPD
2,000
0
CAPD
2,000
0
CCPD
Tidal exchange
2,000
Reserve volume
0
Tidal dialysis
2,000
0
Semiautomated PD
8:00
12:00
4:00
8:00
12:00
4:00
8:00
Time

PD Rx: Modality

Determinants of Modality Choice

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

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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

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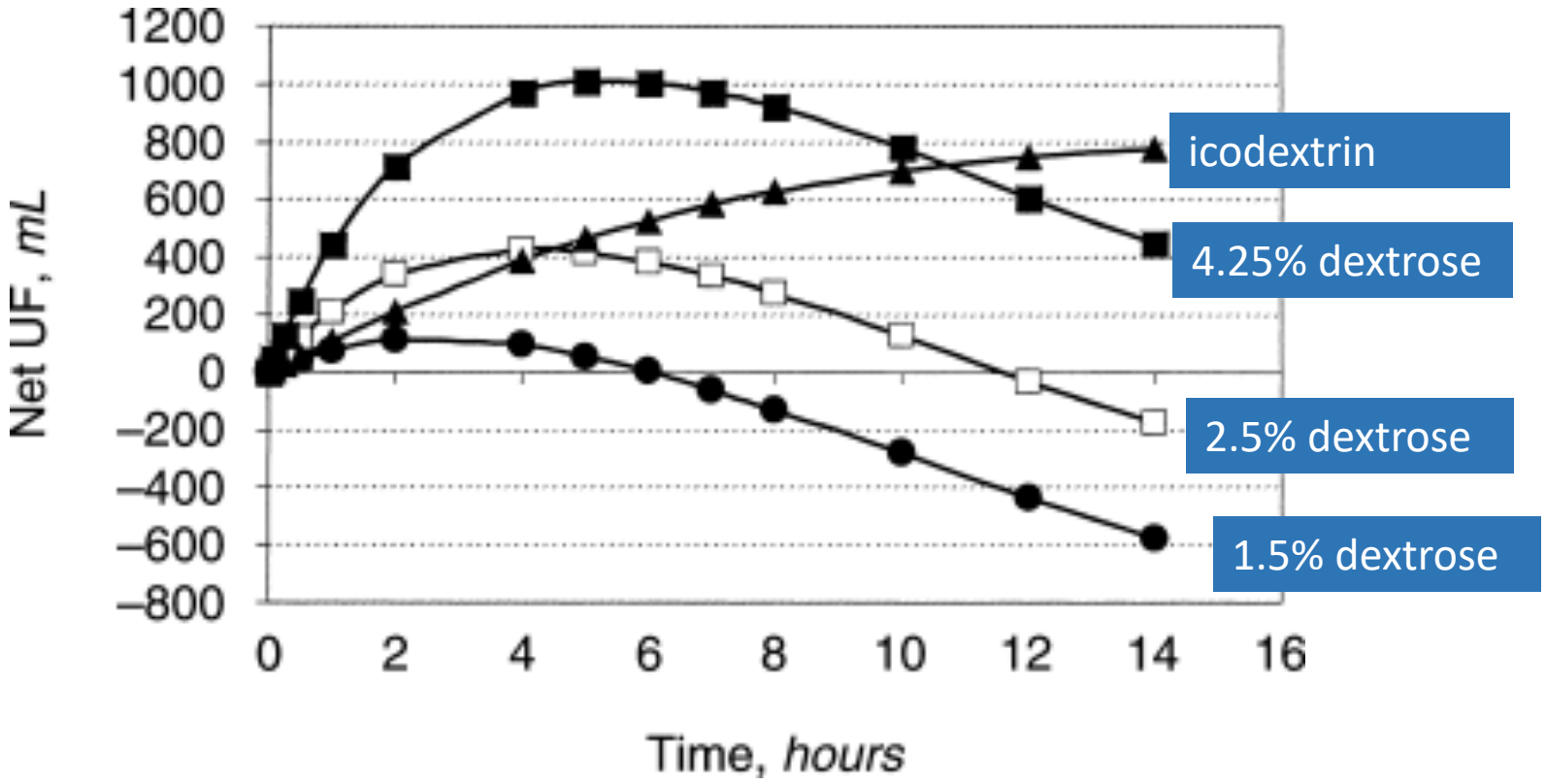
PD Rx: Solution



Kidney International 2002 62, S17-S22DOI: (10.1046/j.1523-1755.62.s81.4.x)

Solutions

Table 1 | Selected peritoneal dialysis solutions currently available in Europe

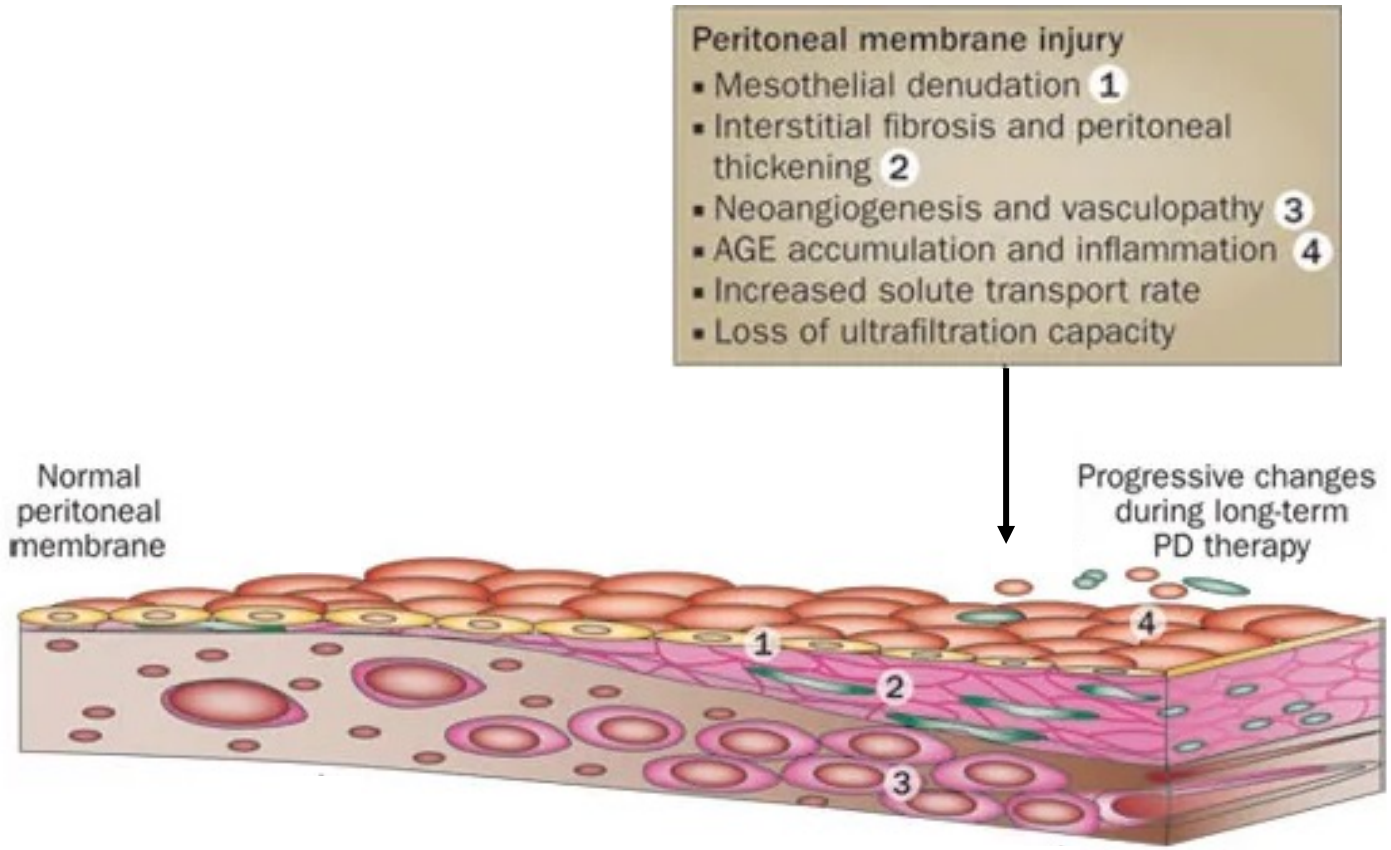
Solution (manufacturer)	pH	Chambers	Buffer	Osmotic agent	GDPs	Advantages	Disadvantages
Dianeal® (Baxter*)	5.2	Single	Lactate	Glucose	High	Easy to manufacture; low cost	Low pH; poor peritoneal membrane biocompatibility; infusion pain; contains lactate
Extraneal® (Baxter*)	5.6	Single	Lactate	Icodextrin	Low	Sustained ultrafiltration; reduced	Contains lactate; low pH; single daily use only; hypersensitivity
Nutrineal® (Baxter*)	5.5	Single	Lactate	Amino acids	No	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		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

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

Glucose degradation products

Delflex

Effects of Conventional Solutions



Nature Reviews Nephrology 8:224-233, 2012

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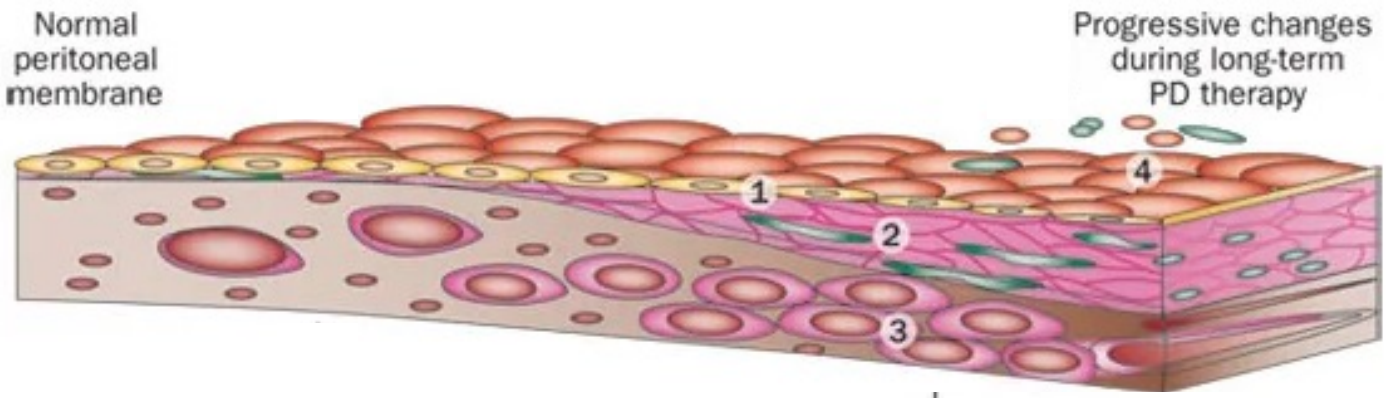
Effects of Conventional Solutions



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

Suboptimal patient and technique survival

Nature Reviews Nephrology 8:224-233, 2012

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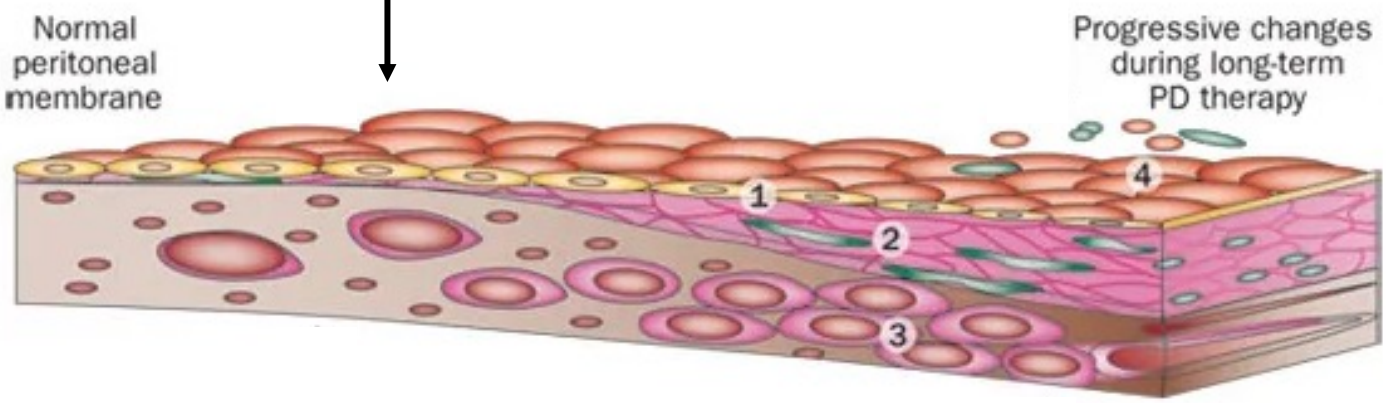
Biocompatible Solutions

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



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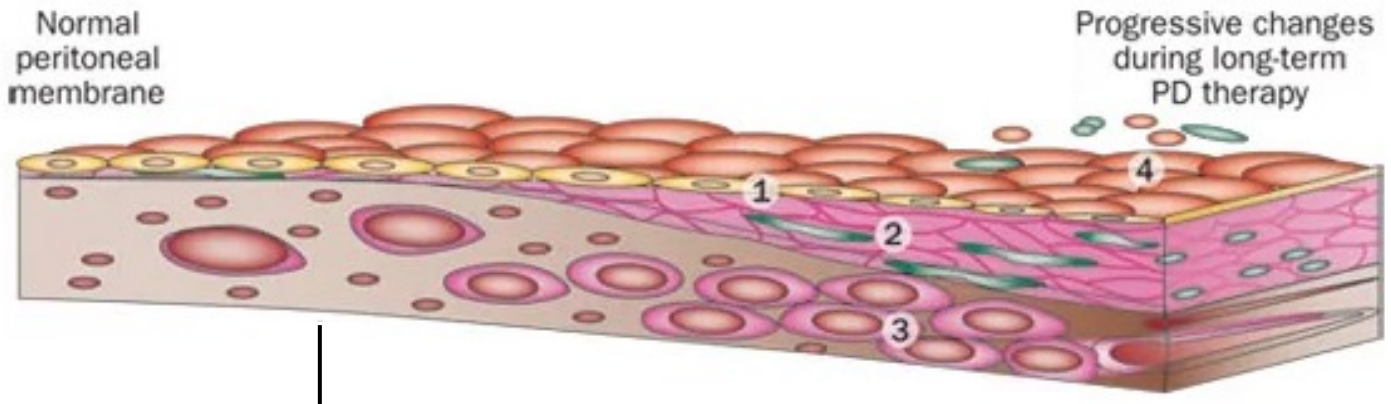
Effects of Biocompatible Solutions



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?

Nature Reviews Nephrology 8:224-233, 2012

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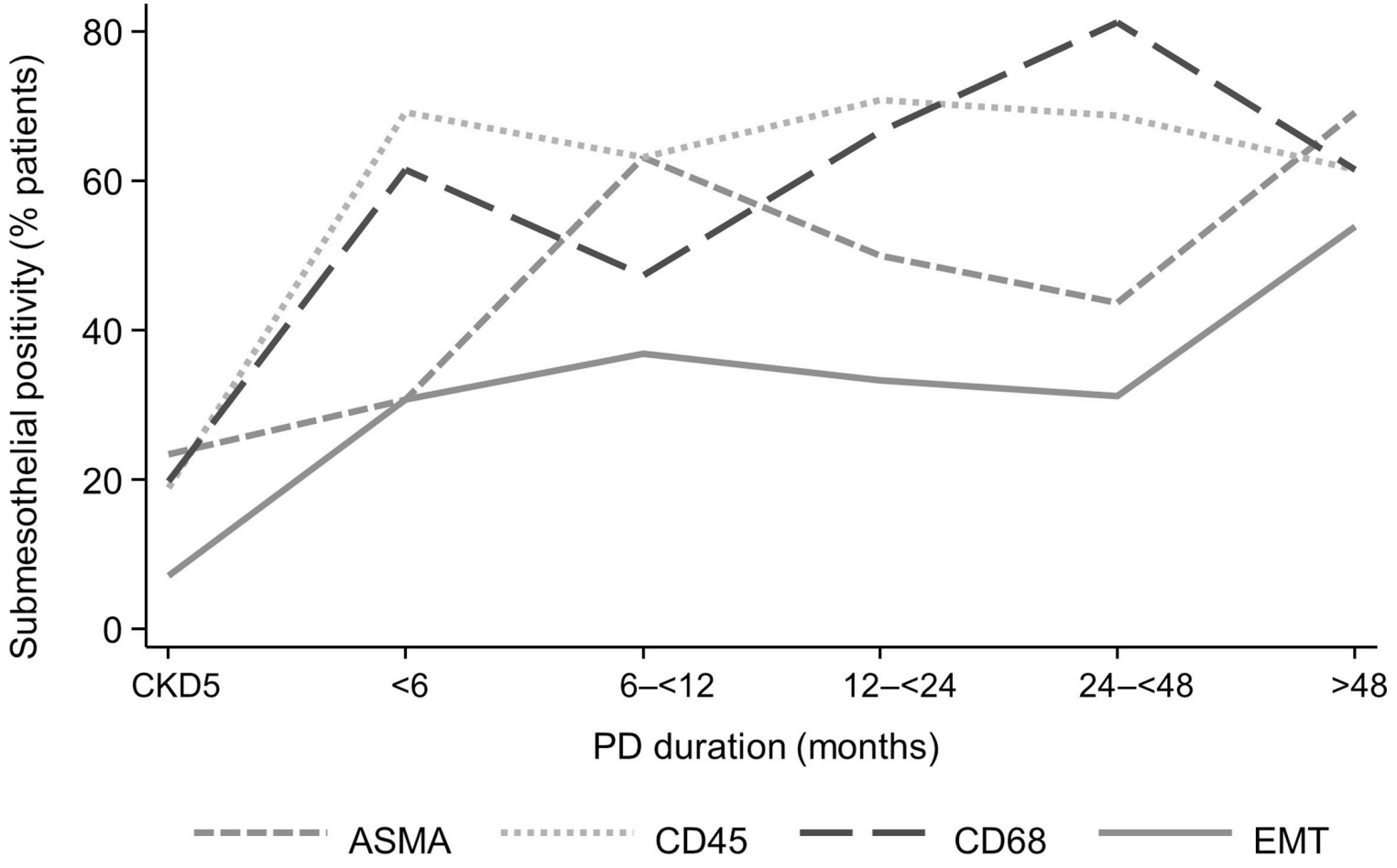
Biocompatible Solutions in Children



Kidney International (2018) **94,** 419–429; https://doi.org/10.1016/j.kint.2018.02.022

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PD Rx: Solution

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

Il-Soo Ha[1], Hui K. Yap[2], Reyner L. Munarriz[3], Pedro H. Zambrano[4], Joseph T. Flynn[5], Ilmay Bilge[6], Maria Szczepanska[7], Wai-Ming Lai[8], Zenaida L. Antonio[9], Ashima Gulati[10], Nakysa Hooman[11], Koen van Hoeck[12], Lina M.S. Higuita[13], Enrico Verrina[14], Günter Klaus[15], Michel Fischbach[16], Mohammed A. Riyami[17], Emilja Sahpazova[18], Anja Sander[19], Bradley A. Warady[20] and Franz Schaefer[21] for the International Pediatric Peritoneal Dialysis Network (IPPN) Registry[22]

- 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)

Kidney Int. 2015 Sep; 88(3): 605–613.

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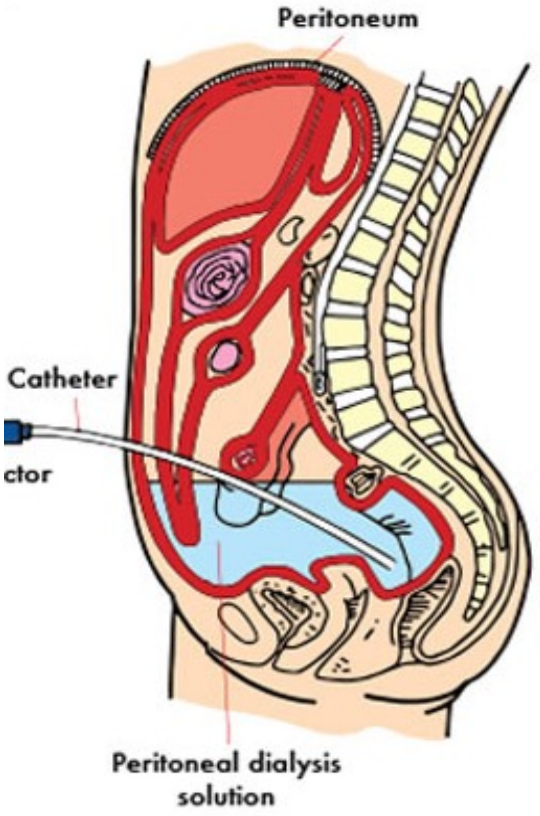
PD Rx: Fill Volume

- 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

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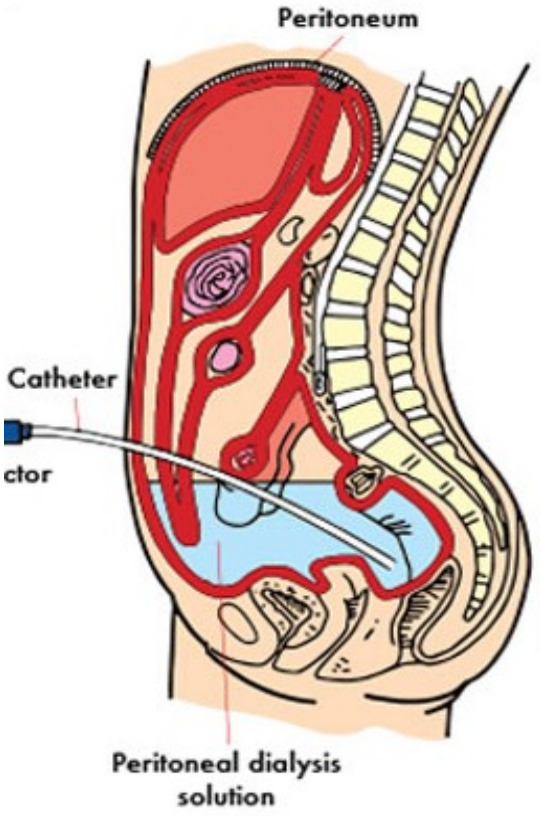
PD Rx: Fill Volume

APD:

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



CAPD:

- 600-800 mL/m^2 (day)
- 800-1000 mL/m^2 (night)

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Measuring IPP

Intra-peritoneal pressure maximum 18 cm H_2O

Normal 7-14 cm H_2O

- 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

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

Pediatr Nephrol (2003) 18:976-980

PD Rx: Excess Volume

Intra-peritoneal pressure maximum 18 cm H_2O

Normal 7-14 cm H_2O

Excess volume:

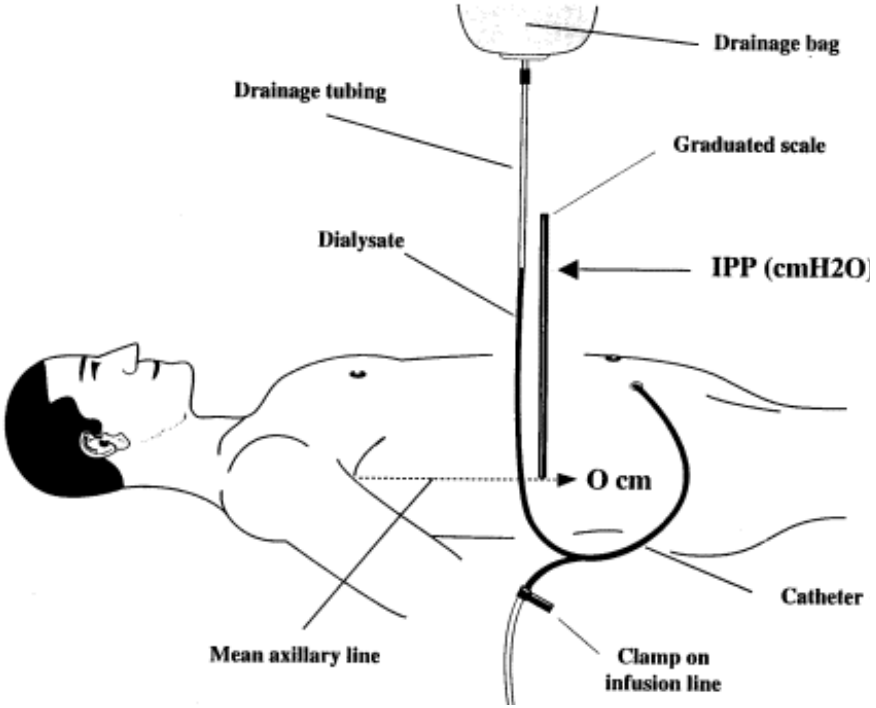
-Loss of UF

-Pain

-Risk of hernia

-Risk of hydrothorax

-Risk of breathing problems



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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

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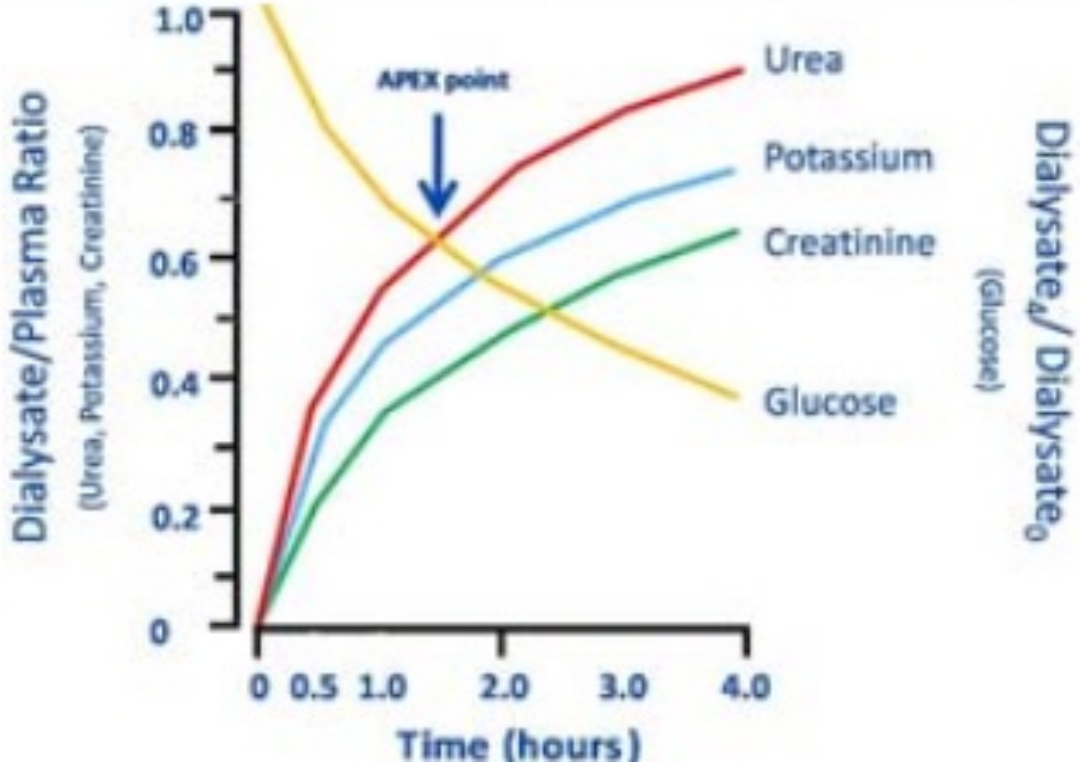
PD Rx: Dwell Time

Accelerated Peritoneal Examination
APEX time indicates optimal dwell time for UF



Fischbach et al Perit Dial Int. 1996; 16 Suppl 1:S557-60

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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

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PD Rx cheat sheet

Automated PD

Solution:

1.5%, 2.5% or 4.25% dianeal

Fill volume (nocturnal):

< 2years old = 600-800 mL/m^2

> 2 years old = 1100-1400 mL/m^2

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/m^2

Long overnight dwell(nocturnal):

800-1000 mL/m^2

 # 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

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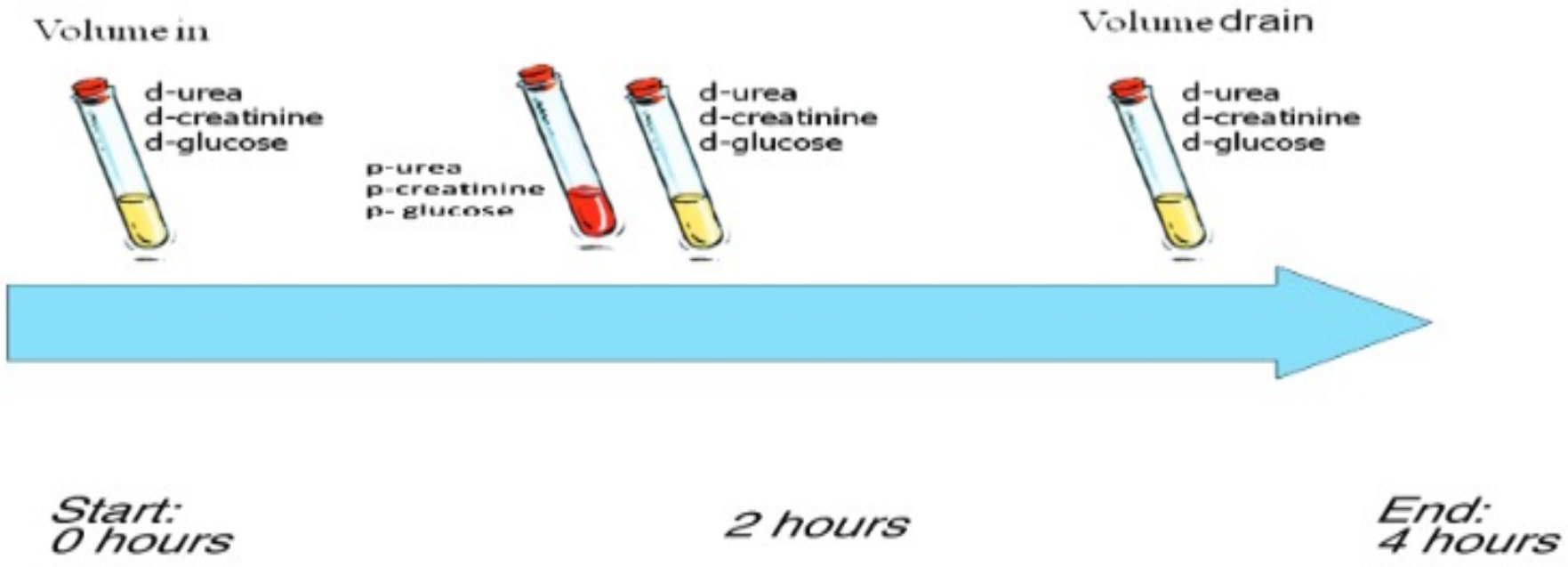
Peritoneal Equilibration Test (PET)

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



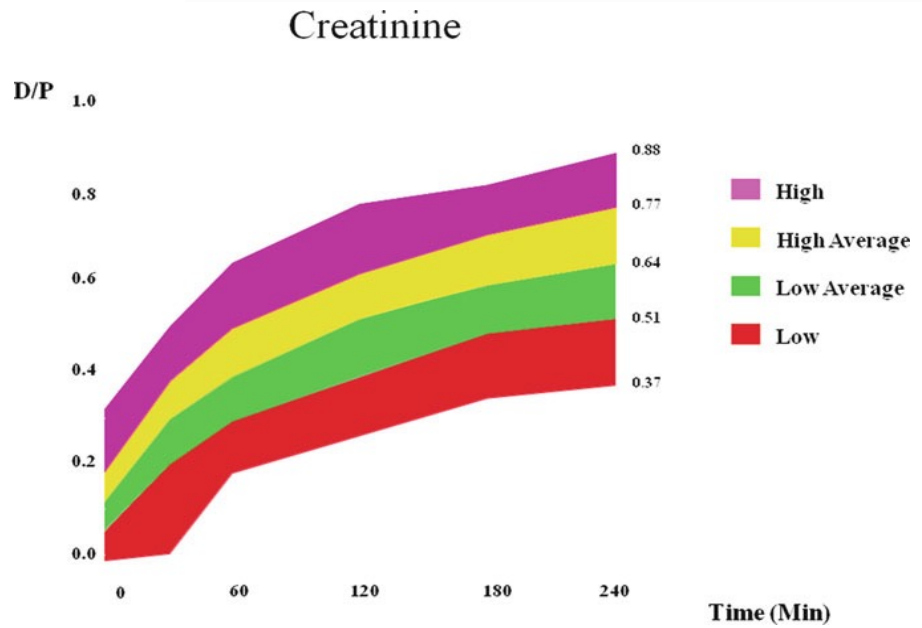
Nephrol Dial Transplant (2010) 25: 2052–2062

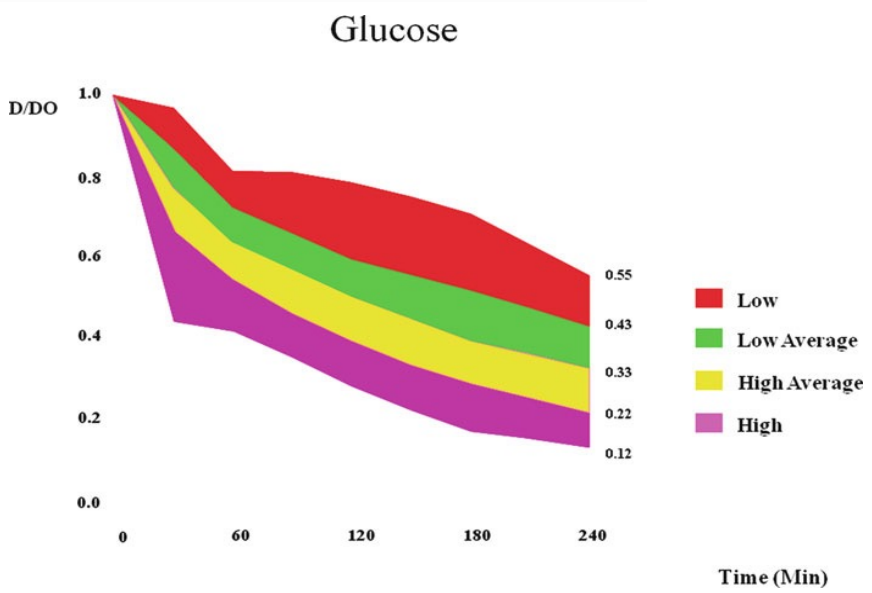
NKF KDOQI Guidelines 2006

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

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





Warady BA et al. JASN November 1996, 7(11):2385-2391

Pediatric Dialysis book, 3rd edition, 2021

PET: Transporter Type

Transporter Type	Characteristics	Prescription
High	-Highly permeable membrane -Rapid solute clearance -Loss of osmotic gradient quickly (poor UF) -Higher protein loss (lower albumin)	-Shorter dwell times -NIPD, or APD with icodextrin daytime fill
High Average	-Efficient membrane -Good solute clearance -Good UF	-Any dialysis regimen
Low Average	-Less efficient membrane -Slower solute clearance -Good UF	-Any dialysis regimen, but with fewer cycles
Low	-Low membrane permeability -Slow solute clearance -Very good UF -Lower protein loss (higher albumin)	-Larger fill volumes -Longer duration of dwell with less cycles -CAPD or CCPD

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PD Rx: Modeled Approach

Kinetic Modeling Software Based Programs

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

*Pediatr Nephrol. 2001 Mar; 16(3):205-11

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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

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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

NKF KDOQI Guidelines 2006

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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

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

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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

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

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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"

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

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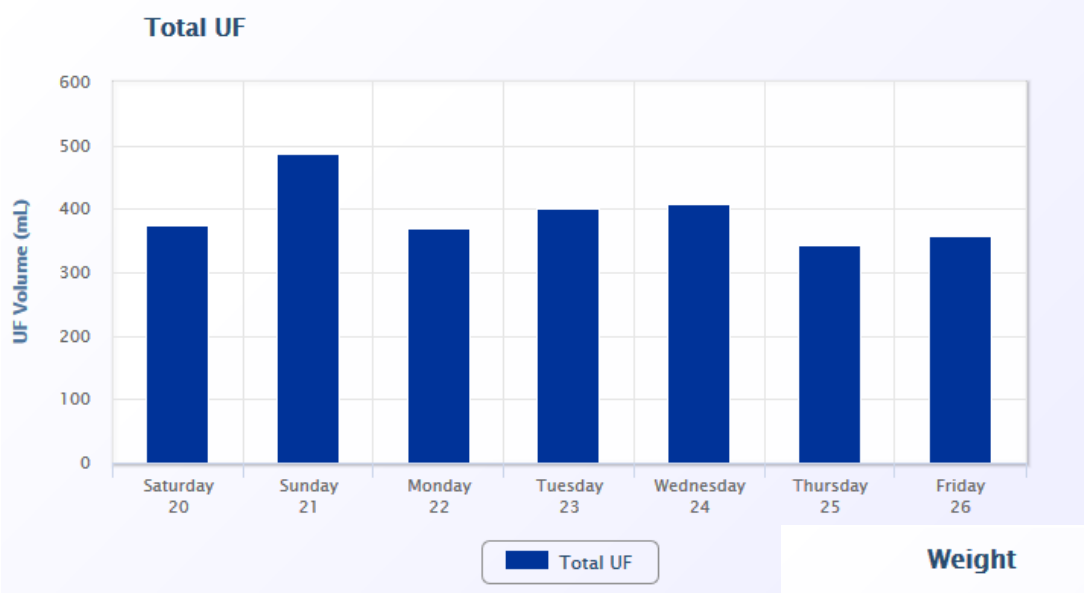
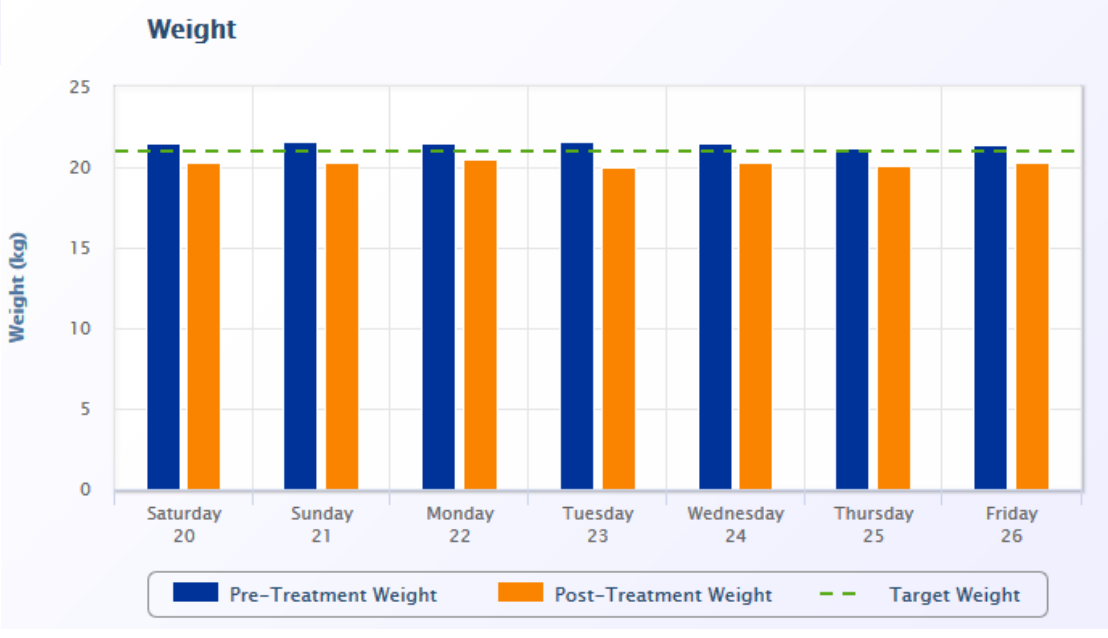
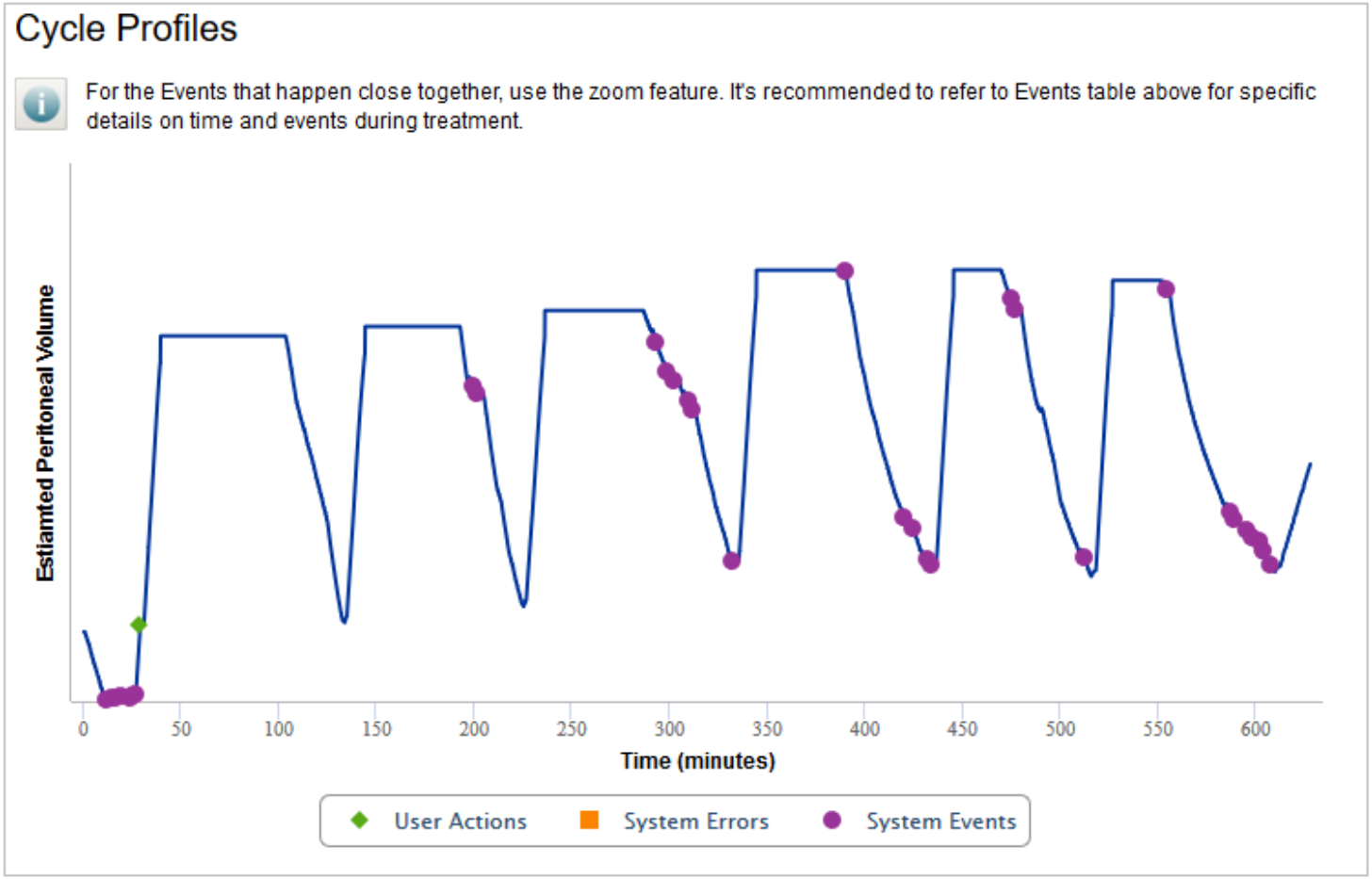
PD Rx: Assessment





PD Rx: Assessment



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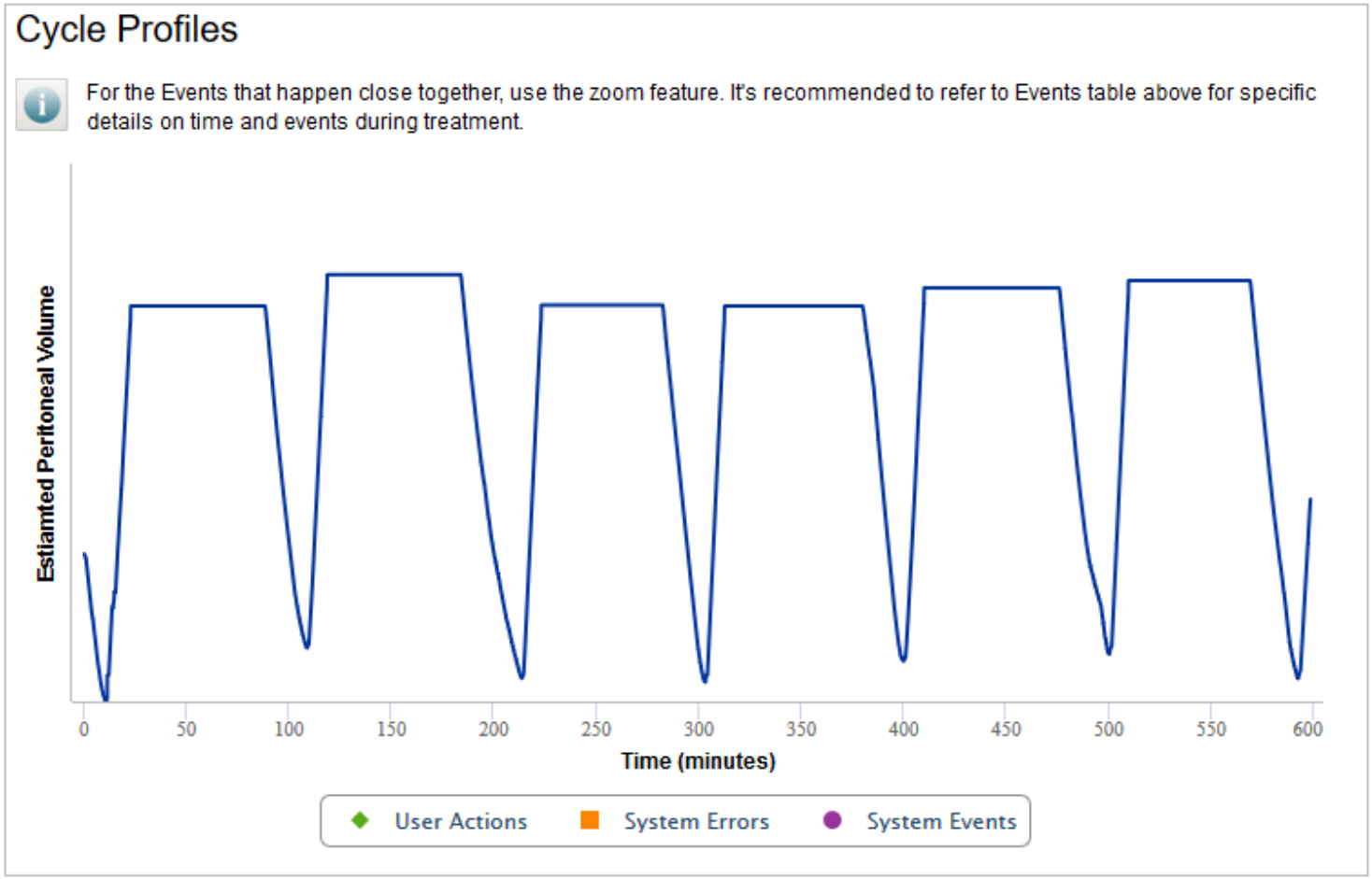
PD Rx: Assessment



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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.*

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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

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

Weekly Peritoneal Dialysis Kt/V

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

Weekly Renal Kt/V

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

Daily Renal Urea Clearance

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

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Total Body Water Calculation

$$\text{Males: TBW} = 0.010 \cdot (\text{height} \cdot \text{weight})^{0.68} - 0.37 \cdot \text{weight}$$

$$\text{Females: TBW} = 0.14 \cdot (\text{height} \cdot \text{weight})^{0.64} - 0.35 \cdot \text{weight}$$

NKF KDOQI Guidelines 2006

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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	16.5										
24	11.8	12.3	12.9	13.4	13.8	14.4	14.8	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	18.8	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	21.9	22.4	23.0	23.7	24.3	24.9	25.6	26.2	26.8	27.4	
40			16.0	16.7	17.4	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			16.3	17.0	17.8	18.5	19.2	20.0	20.7	21.4	22.1	22.9	23.5	24.2	24.9	25.5	26.2	26.9	27.5	28.2	28.8	29.5
44			16.6	17.3	18.1	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			16.8	17.6	18.4	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			17.1	17.9	18.7	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			17.3	18.2	19.0	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	22.6	23.5	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	23.0	23.8	24.7	25.5	25.3	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	25.7	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	24.6	25.5	26.4	27.4	28.3	29.2	30.1	31.0	31.9	32.8	33.7	34.5	35.4	36.3
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	35.6	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	29.0	30.0	31.0	32.0	33.0	34.0	34.9	35.9	36.9	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	31.6	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

Weight (kg) \ Height (cm)	50	54	58	62	66	70	74	78	82	86	90	94	98	102	106	110	114
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

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	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	
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_{urea}=1.7
  - *If less than 1.7 and otherwise doing well, should not have PD prescription increased for sole purpose of meeting target*

Prescribing peritoneal dialysis for high-quality care in children.
Perit Dial Int 2020; 40(3)333-340.

Duke Children's

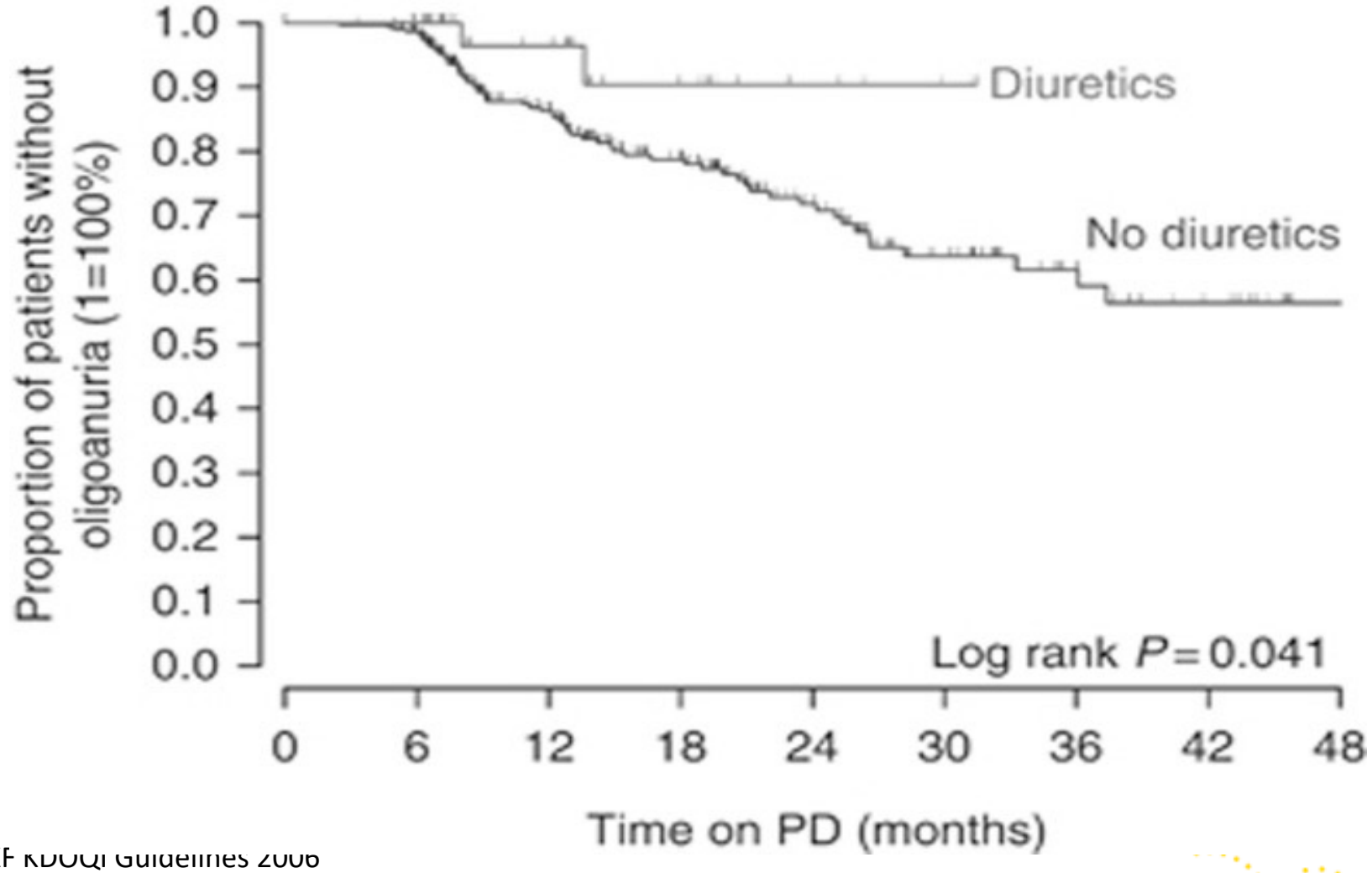
Residual Kidney Function

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

NKF KDOQI Guidelines 2006

Duke Children's

Residual Kidney Function



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

Kidney Int. 2015 Sep; 88(3): 605–613. *-340.*

Duke Children's

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

Duke Children's

Summary

- PD prescription must be individualized and optimized, and continually re-assessed
- While recommended minimal "delivered" dose of solute clearance should be a Kt/V_{urea} 1.7/week, adequacy is also determined by clinical outcomes of the patient
  - BP control, fluid management, growth, nutrition, bone disease, development, and quality of life

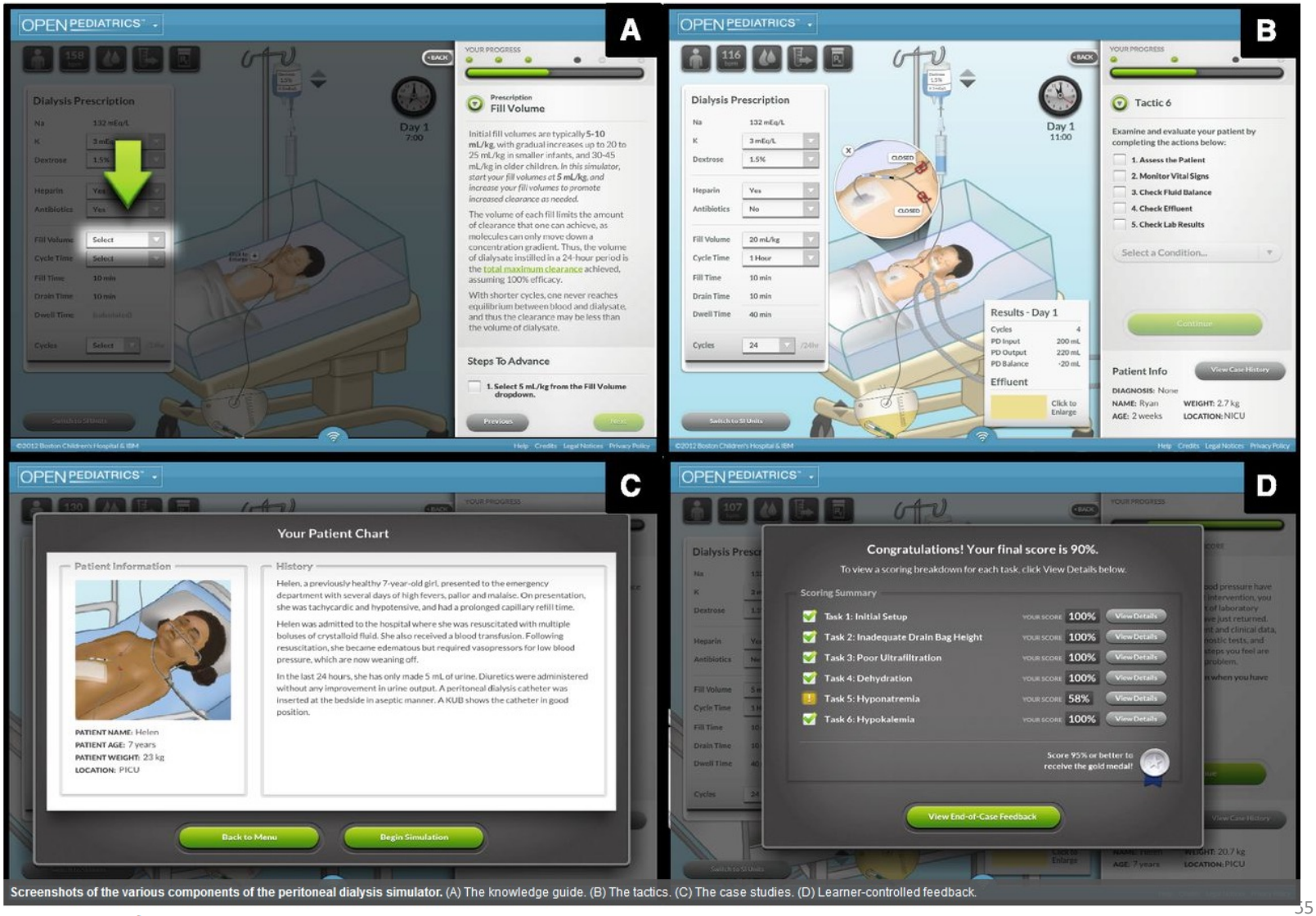
Useful Resources

- 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 Childrren 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



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.

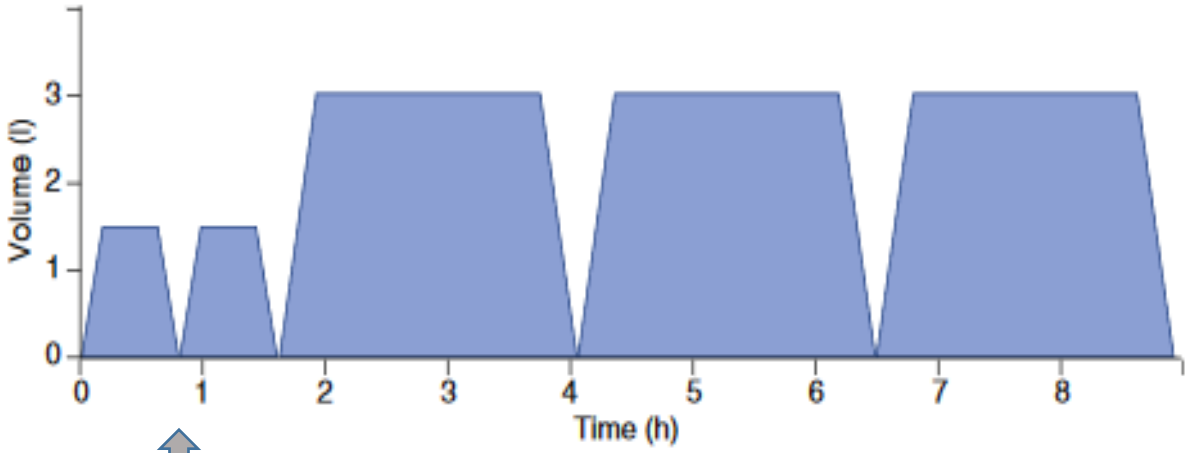
CJASN June 2018, 13 (6) 900-906;

???Questions???

Thank you!

Duke Children's

Adapted APD



Water and
small molecules

Sodium and
large molecules
(uremic toxins)

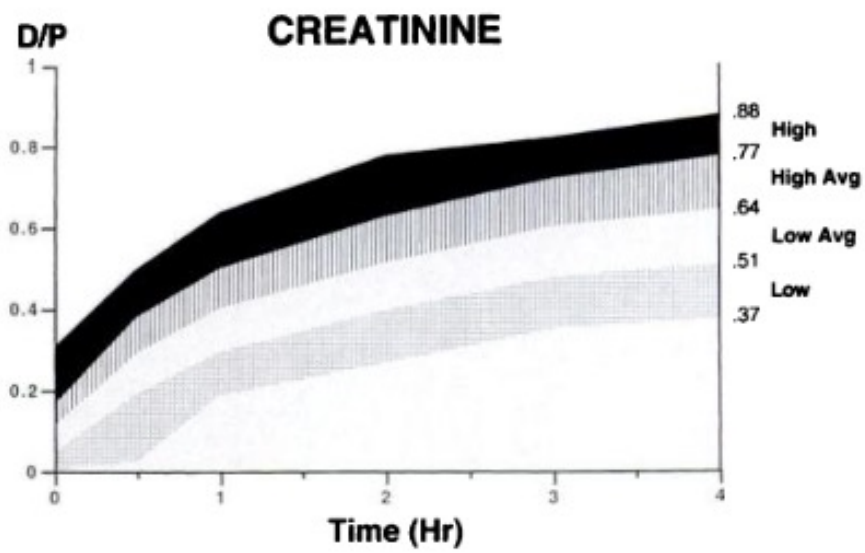
Fischbach et al Kidney International (2016) 89: 761-766

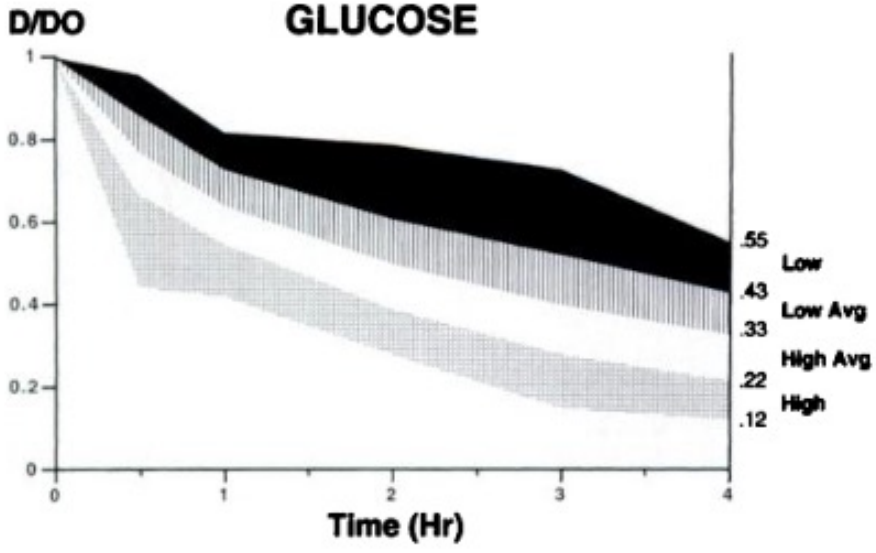
Duke Children's

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

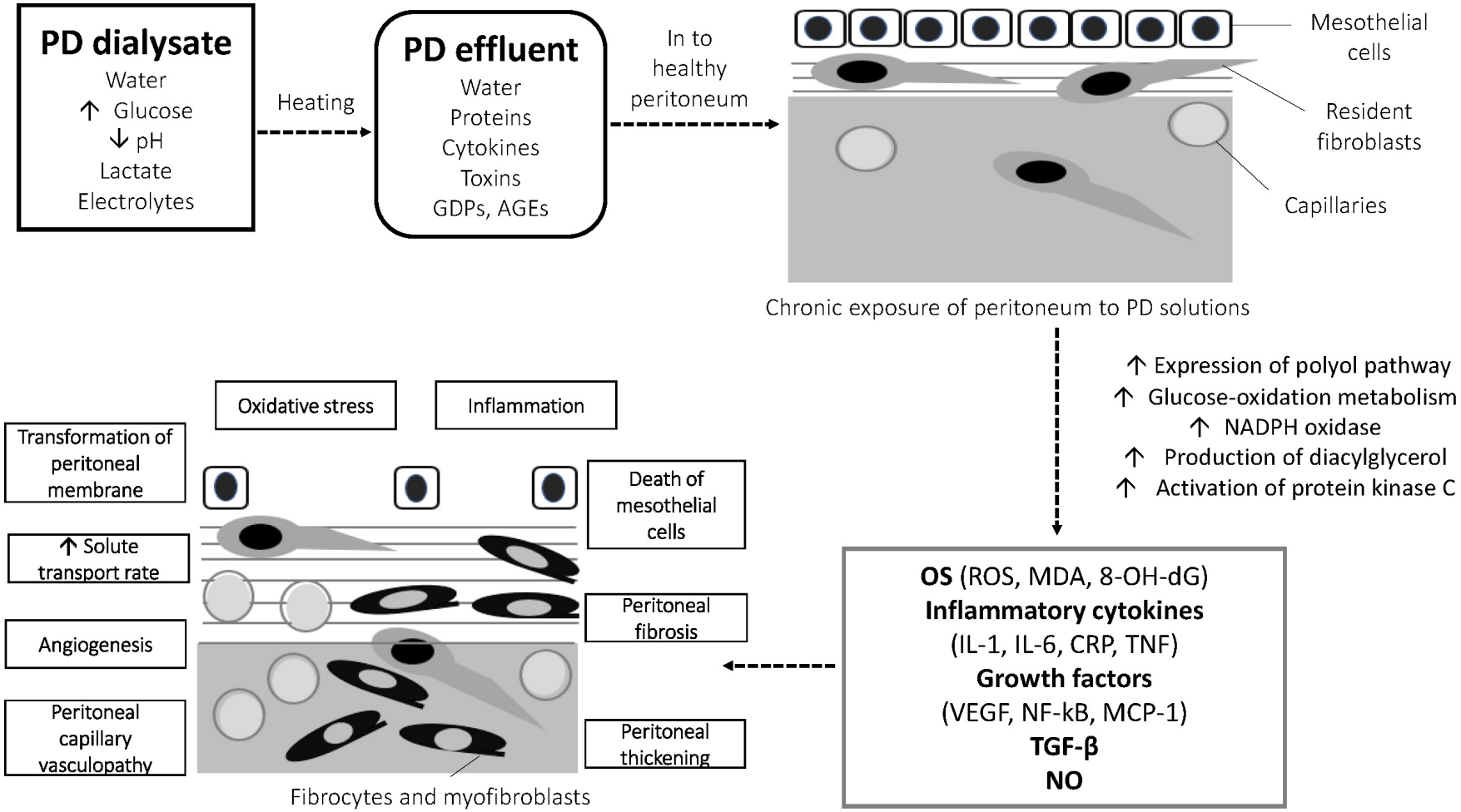
[a]At a 4 h dwell of an exchange performed with 1,100 ml/m² BSA of a 2.5% dextrose solution





B A Warady, S R Alexander, S Hossli, E Vonesh, D Geary, S Watkins, I B Salusky and E C Kohaut
JASN November 1996, 7 (11) 2385-2391;

Effects of Conventional Solutions



Roumeliotis S, et al. Unfavorable Effects of Peritoneal Dialysis Solutions on the Peritoneal Membrane: the Role of Oxidative Stress. Biomolecules 2020, 10(5):768.

Duke Children's

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

Duke Children's