Assessment of the Peritoneal Membrane: Practice Workshop

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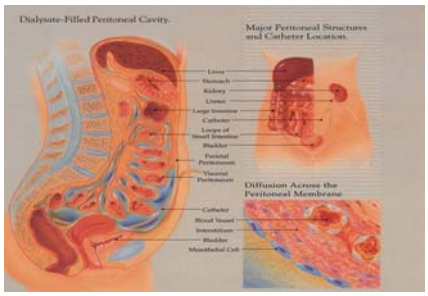
Objectives

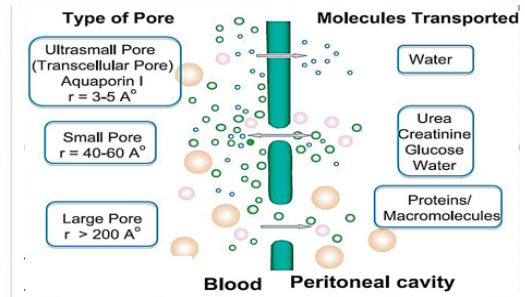
- Briefly review normal peritoneal physiology including the three pore model.
- Compare and contrast the basic concepts of the Standard Peritoneal Equilibration Test (PET) vs. other tests for accurate peritoneal membrane assessment.
- Discuss the process the clinician uses to ensure PET validity.
- Using the standard PET, participate in a workshop and develop best practice to maximize patient prescriptions.

Review of Physiology



(Fresenius Kidney Care, 2013)

Three Pore Model



(Fresenius Kidney Care, 2013)

Tests to Determine Peritoneal Membrane Transport Status

FAST Peritoneal Equilibration Test

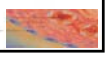
- A variation of the PET
- 4 hour creatinine and glucose tested *only*
- Less labor intensive for the staff and patient
- Determinations of membrane transport similar to standard PET

(Guest, 2010)

Modified PET

- This is a variation of the PET
- Uses a 4.25% solution to test for ultrafiltration failure (UFF) (Type 1 aquaporin)
- Exposes the membrane to a maximum osmotic pull during the test
- The same samples are drawn as per the standard PET with a sodium sample added and a test is done at the 0,1,2 and 4 hr. marks
- Total UF<400 validates UFF

(Guest, 2010)



Dialysis Adequacy and Transport Test(DATT)

- A variation of the PET
- A single blood draw and one aliquot of a pooled CAPD 24 hour sample
- Daily ultrafiltration information recorded
- Less labor intensive for the staff and patient
- Determinations of membrane transport similar to standard PET

(Guest, 2010)

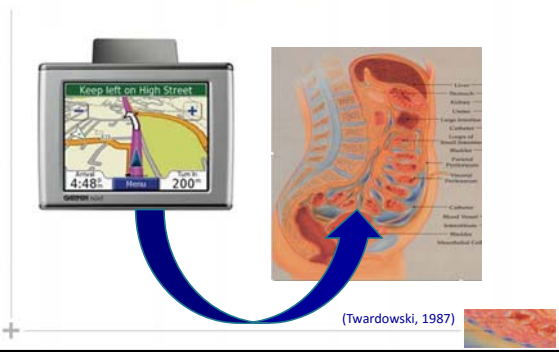
Peritoneal Dialysis Capacity (PDC)

- A variation of the PET
- Used internationally, not in the US
- Estimates characteristics using specific computer modeling
- Determinations of membrane transport
- Discussed in Van Biesen's publication

(Van Biesen et al, 2006)

Peritoneal Equilibration Test
(Standard PET)

Peritoneal Equilibration Test (PET)



(Twardowski, 1987)

Mechanics of the PET

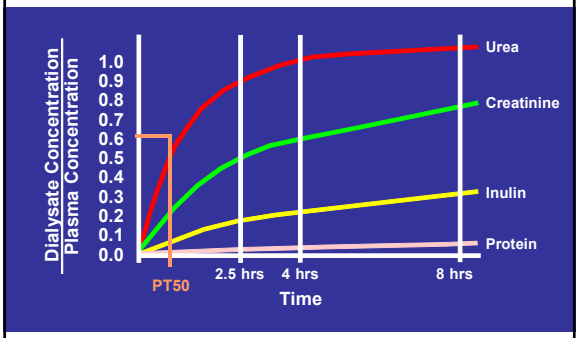
- Smooth catheter performance is a must
- Blood sugar<235 mg/dl
- Night dwell of at least 8 hrs.
- Drain completely at clinic
- 2L 2.5% fill over 10-15 min rolling recumbent
- Draw 0, 2, 4 hour dialysate samples
- Blood sample at 2 hours
- Weigh dialysate and record

Timely and Precise

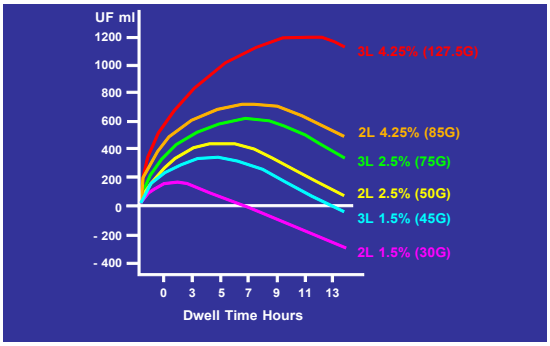
Prepare for a Valid PET

- Prepare the patient prior to the test
  - Accurate prescription, 8 hr. overnight dwell
  - Prevent constipation, high blood sugar, dehydration, missed treatments
- Ensure *complete drain* prior to the test
- Recline the patient and dance in the chair!
- *Validate* the blood sugar is < 235 mg/dl
- Keep the test *on time*
- Draw and label specimens *accurately*

Transport of Different Solutes



Idealized Ultrafiltration Curves



Peritoneal Membrane Characteristics[3]

% Patients[15]	Membrane Type[3]	4-Hr D/P Creatinine	Characteristics
15%	HIGH	.82 – 1.03	• Very efficient membrane • Transports solutes quickly • Increased glucose absorption • May have difficulty achieving ultrafiltration • At risk for loss serum albumin[3]
37%	HIGH-AVERAGE	.65 – .81	• Efficient membrane • Transports solutes well • Ultrafilters well
33%	LOW-AVERAGE	.50 – .64	• Less efficient membrane • Transports solutes somewhat slowly • Ultrafilters well
15%	LOW	.34 – .49	• Inefficient membrane • Transports solutes slowly • Difficult to clear fluid when no residual renal function • Ultrafilters very well

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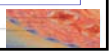
High Average and Low Average Transporters

High Average (37%)	Low Average (33%)
• **Good solute transport**	• *OK solute transport*
• *OK ultrafiltration*	• **Good ultrafiltration**
	
Fast & Quick	**Low and Slow**

(Fresenius Kidney Care, 2014)



Prescriptions to Match the Membrane

High Transporter Prescriptions

- CCPD/APD highly recommended
- Require shorter dwell times, but never less than 90 minutes
- Prescription 9-10 hours, 4-5 cycles, with a last fill
- May need to be dry for a portion of the day related to reabsorbing fluid

Low Transporters Prescription

- CCPD/APD or CAPD
- Dwell greater than 2 to 5 hours CCPD/APD
- Longer dwells allow for more toxin and fluid clearance
- Prescription 9-10 hours, 2-3 cycles with last fill dextrose
- Require day fill, recommended high dose (day exchange) to achieve solute clearance

(Baxter, 2006)
(Fresenius Kidney Care, 2014)

Standard PET Curves

Membrane Transport Type	4-hour D/P Creatinine
HIGH	.82 – 1.03
HIGH-AVERAGE	.65 – .81
LOW-AVERAGE	.50 – .64
LOW	.34 – .49

Twardowski ZJ. Clinical Value of Standardized Equilibration Test in CAPD Patients. Current Concepts of CAPD. Blood Purif 1988;7:96-108

Transport Classifications

	4HR D/P UREA	4HR D/P CREATININE	4HR D/DO GLUCOSE	PT 30 UREA	PT 30 CREATININE	PT 30 GLUCOSE	UF VOLUME
HIGH	.95-1.09	.82-1.09	.12-.25	0.5	0.5	0.5	1580-2084
HIGH AVERAGE	.92-.97	.66-.81	.26-.37	1.1	1.8	1.8	2085-2367
AVERAGE	0.91	0.65	0.38	1.6	2.9	2.9	2368
LOW AVERAGE	.84-.90	.50-.64	.39-.49	2.3	4.8	4.8	2369-2650
LOW	.75-.83	.34-.49	.50-.61	2.8	6.8	6.8	2651-3266

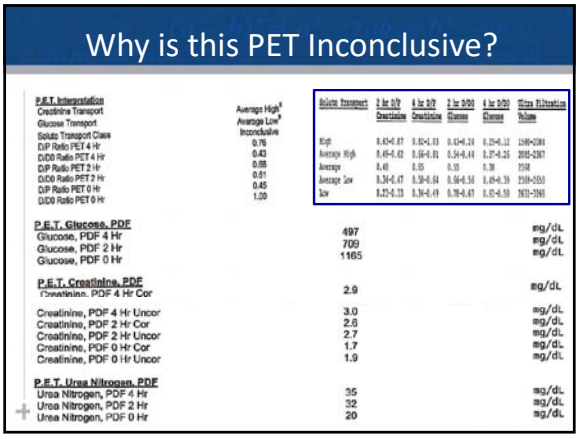
7 Step PET Validation Process

1. Is the blood sugar < 235 mg/dl ?
2. Locate PET Interpretation: Creatinine and glucose transport-*Do the membrane types agree?*
3. Is the solute transport class inconclusive? Why?
4. D/P Ratio PET 4 hour and D/DO PET 4 Hour *Do the numbers agree as to type?*

7 Step PET Validation Process

5. PET Glucose PDF, 0 Hr: Is it >2000-2200 ml for a 2 L 2.5% bag? (If it is less, the patient did not drain well and it is not accurate.)
6. Is the PET glucose PDF 0 Hour value the highest and ***progressively decreases*** to the 2 and 4 hour values?
7. Is the PET PDF 0 hour Corrected Creatinine 0 to < 0.2 and ***progressively increases*** to the 2 and 4 hour values?

Why is this PET Inconclusive?



P.E.T. Interpretation
Creatinine Transport
Glucose Transport
Solute Transport Class
D/P Ratio PET 4 Hr
D/D0 Ratio PET 4 Hr
D/P Ratio PET 2 Hr
D/D0 Ratio PET 2 Hr
D/P Ratio PET 0 Hr
D/D0 Ratio PET 0 Hr

Average High
Average Low
Inconclusive
0.76
0.43
0.88
0.61
0.45
1.00

Solute Transport	2 hr D/P Creatinine	4 hr D/P Creatinine	2 hr D/D0 Glucose	4 hr D/D0 Glucose	Ultra Filtration Volume
High	0.63-0.87	0.82-1.03	0.43-0.14	0.25-0.12	1340-2284
Average High	0.49-0.62	0.64-0.81	0.34-0.43	0.27-0.26	2035-2367
Average	0.48	0.65	0.35	0.38	2358
Average Low	0.34-0.47	0.58-0.64	0.56-0.56	0.69-0.39	2519-2553
Low	0.23-0.33	0.34-0.49	0.78-0.67	0.92-0.50	2671-2965

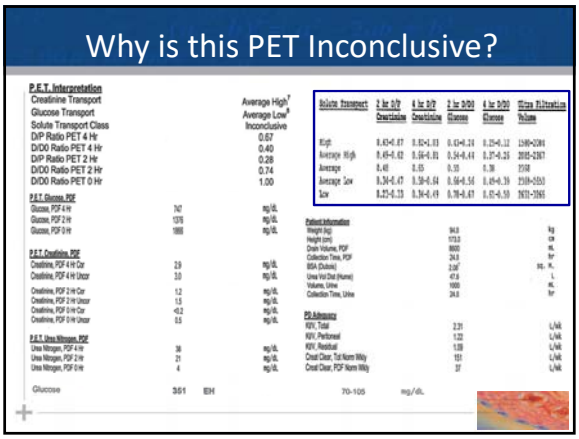
P.E.T. Glucose, PDF
Glucose, PDF 4 Hr 497 mg/dL
Glucose, PDF 2 Hr 709 mg/dL
Glucose, PDF 0 Hr 1165 mg/dL

P.E.T. Creatinine, PDF
Creatinine, PDF 4 Hr Cor 2.9 mg/dL

Creatinine, PDF 4 Hr Uncor 3.0 mg/dL
Creatinine, PDF 2 Hr Cor 2.6 mg/dL
Creatinine, PDF 2 Hr Uncor 2.7 mg/dL
Creatinine, PDF 0 Hr Cor 1.7 mg/dL
Creatinine, PDF 0 Hr Uncor 1.9 mg/dL

P.E.T. Urea Nitrogen, PDF
Urea Nitrogen, PDF 4 Hr 35 mg/dL
Urea Nitrogen, PDF 2 Hr 32 mg/dL
Urea Nitrogen, PDF 0 Hr 20 mg/dL

Why is this PET Inconclusive?



P.E.T. Interpretation
Creatinine Transport
Glucose Transport
Solute Transport Class
D/P Ratio PET 4 Hr 0.67
D/D0 Ratio PET 4 Hr 0.40
D/P Ratio PET 2 Hr 0.28
D/D0 Ratio PET 2 Hr 0.74
D/D0 Ratio PET 0 Hr 1.00

Average High
Average Low
Inconclusive

Solute Transport	2 hr D/P Creatinine	4 hr D/P Creatinine	2 hr D/D0 Glucose	4 hr D/D0 Glucose	Ultra Filtration Volume
High	0.63-0.87	0.82-1.03	0.43-0.14	0.25-0.12	1340-2284
Average High	0.49-0.62	0.64-0.81	0.34-0.43	0.27-0.26	2035-2367
Average	0.48	0.65	0.35	0.38	2358
Average Low	0.34-0.47	0.58-0.64	0.56-0.56	0.69-0.39	2519-2553
Low	0.23-0.33	0.34-0.49	0.78-0.67	0.92-0.50	2671-2965

P.E.T. Glucose, PDF
Glucose, PDF 4 Hr 747 mg/dL
Glucose, PDF 2 Hr 1376 mg/dL
Glucose, PDF 0 Hr 1868 mg/dL

P.E.T. Creatinine, PDF
Creatinine, PDF 4 Hr Cor 2.9 mg/dL
Creatinine, PDF 4 Hr Uncor 3.0 mg/dL
Creatinine, PDF 2 Hr Cor 1.2 mg/dL
Creatinine, PDF 2 Hr Uncor 1.5 mg/dL
Creatinine, PDF 0 Hr Cor <0.2 mg/dL
Creatinine, PDF 0 Hr Uncor 0.5 mg/dL

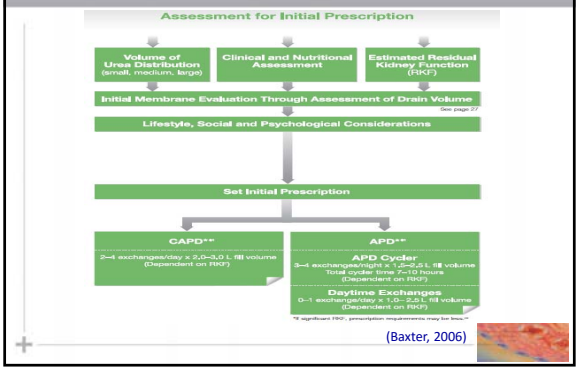
P.E.T. Urea Nitrogen, PDF
Urea Nitrogen, PDF 4 Hr 36 mg/dL
Urea Nitrogen, PDF 2 Hr 21 mg/dL
Urea Nitrogen, PDF 0 Hr 4 mg/dL

Glucose 361 EH 70-105 mg/dL

Patient Information
Weight (kg) 94.0 kg
Height (cm) 173.0 cm
Drain Volume, PDF 8000 mL
Collection Time, PDF 24.0 hr
BSA (Dubois) 2.07 sq. m.
Urea Vol Dist (Hume) 47.6 L
Volume, Urine 1000 mL
Collection Time, Urine 24.0 hr

PD Adequacy
KRV, Total 2.21 L/wk
KRV, Peritoneal 1.22 L/wk
KRV, Residual 1.00 L/wk
Creat Clear, Tot Norm Wdy 151 L/wk
Creat Clear, PDF Norm Wdy 37 L/wk

Initial Prescription



(Baxter, 2006)

Individualizing Therapy

- Patients with higher D/P require an increased number of exchanges during the night
- Patients with higher BSA require higher fill volume per exchange
- Anuric patients are advised to have an extra day exchange
- Icodextrin may be considered in patients during a long day dwell as it can improve the UF and clearance of patients

(Baxter, 2006)

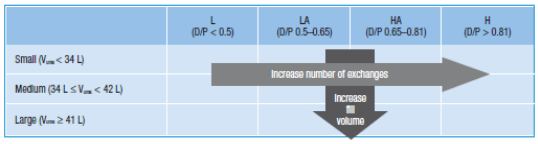


Figure illustrates the need to augment the number of exchanges as D/P creatinine increases and to increase fill volume with increase in V.

Let's Practice!

Case Study #1

25 yo male, single (twin)
F/T hotel clerk
Transfer from HD (2 mos)
Lupus nephritis, HTN
64.6 kg (142 lb)
178 cm (5'10")
50cc UO
Transport Status?

Solute Transport	2 hr D/P Creatinine	4 hr D/P Creatinine	2 hr D/D0 Glucose	4 hr D/D0 Glucose	Ultra Filtration Volume
High	0.43–0.67	0.82–1.03	0.43–0.14	0.25–0.12	1500–2004
Average High	0.49–0.62	0.64–0.81	0.54–0.44	0.37–0.25	2005–2267
Average	0.46	0.65	0.35	0.38	2538
Average Low	0.34–0.47	0.58–0.64	0.66–0.55	0.48–0.39	2539–2810
Low	0.22–0.33	0.34–0.49	0.78–0.67	0.61–0.50	2831–3066

D/P Ratio PET 0 Hr	0.02
D/P Ratio PET 2 Hr	0.36
D/P Ratio PET 4 Hr	0.59
D/D0 Ratio PET 0 Hr	1.00
D/D0 Ratio PET 2 Hr	0.63
D/D0 Ratio PET 4 Hr	0.42

Case Study #1

25 yo male, single (twin)
F/T hotel clerk-
Rotates days to middles
Transfer from HD (2 mos)
Lupus nephritis, HTN

64.6 kg (142 lb)
178 cm (5'10")
300-50cc UO
(almost anuric)

Lifestyle?
Body size?
CAPD or CCPD?
Continuous or intermittent?
Number of exchanges?
Dry day or not?
Pause/walk away?
Volume of fills?
Dwell time?

Case Study #1

25 yo male, single (twin)
F/T hotel clerk-
Rotates days to middles
Transfer from HD (2 mos)
Lupus nephritis, HTN

64.6 kg (142 lb)
178 cm (5'10")
300-50cc UO
(almost anuric)

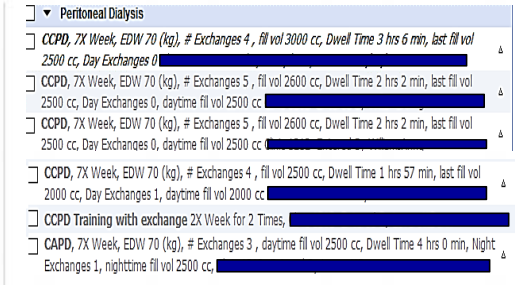
How can we preserve RRF?
Should we add a diuretic?
Does being underweight matter?

Underweight or Overweight
<95% or >115% Standard BW
Adj BW=Edema free BW+
[(standard BW-edema free BW) x 0.25

68 kg+ [(81-68) x .25] = 71.4 kg = 157 lbs

(NKF KDOQI, 2000)

Case Study #1: Prescription



Case Study #2

65 yo married female
Type II diabetes
Retired schoolteacher
Math Tutor afternoons
Husband FT works 2-10 P

48.7 kg (107.4 lb)
144.8 cm (4'9")
24 hr UO=1200 cc

**Can use 1100 ml/m2 of 2.5% PET (Kaku & Honda, 2008)

Solute Transport	2 hr D/P Creatinine	4 hr D/P Creatinine	2 hr D/D0 Glucose	4 hr D/D0 Glucose	Ultra Filtration Volume
High	0.65-0.87	0.82-1.03	0.13-0.28	0.25-0.12	1596-2084
Average High	0.49-0.62	0.66-0.81	0.34-0.44	0.37-0.26	2095-2367
Average	0.48	0.65	0.35	0.38	2598
Average Low	0.34-0.47	0.58-0.64	0.46-0.56	0.49-0.39	2596-2553
Low	0.25-0.33	0.34-0.49	0.78-0.67	0.81-0.59	2653-2866

Blood sugar=160 mg/dl
4 Hour D/P= 0.70
4 Hour D/DO= 0.29

Transport status?

Case Study #2

65 yo married female
Type II diabetes
"Retired" schoolteacher
Tutors 5:30-8 PM M-Th
Husband FT works 12-8 P
Likes to eat dinner with her husband

48.7 kg (107.4 lb)
144.8 cm (4'9")
24 hr UO=1200 cc

Lifestyle?
Body size?
CAPD or CCPD?
Continuous or intermittent?
Number of exchanges?
Dry day or not?
Pause/walk away?
Volume of fills?
Dwell time?

Case Study #2

65 yo married female
Type II diabetes
"Retired" schoolteacher
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Likes to eat dinner with her husband

48.7 kg (107.4 lb)
144.8 cm (4'9")
24 hr UO=1200 cc

How can we preserve RRF?
Should we add a diuretic?
What about her height?
What about her weight?
How do we minimize glucose exposure?
What about her diet?

Case Study #2: Prescription

- CAPD 7xweek, EDW 45(kg), # Exchanges 4, fill volume 1400cc, dwell time 90 minutes, last fill 0, pause 800cc
- CAPD, 7 x week, EDW 45(kg), # Exchanges 5, fill volume 1400cc, dwell time 90 minutes, last fill 0, pause 800 cc
- CAPD, 7xweek, EDW 45(kg), # Exchanges 5, fill vol 1500 cc, Dwell time 2 hours, last fill 800cc , day exchange 0, daytime fill volume 800cc

To Summarize

- The peritoneal capillary, namely the capillary vascular surface area is the critical barrier to peritoneal transport
- There are three pores in the capillary. When the aquaporin pores fail, the capillary membrane loses the ability to ultrafiltrate.
- The PET provides a map of the peritoneum to point the clinician in the right direction when developing a prescription for adequate dialysis.
- The PET is mathematical. It is crucial to prepare your patient and stick to the procedure for accuracy

To Summarize

- Following a troubleshooting algorithm will help the clinician validate PET results and ensure accuracy.
- It is important to consider lifestyle when choosing a prescription. The patient's PET data should be entered into prescription modeling software and the patient should be allowed to choose what they can do.
- Knowing how to optimize the peritoneal prescription by considering preserving RRF, dwell time, dry or wet day, the pause and other factors will allow your patient to achieve Kt/V standards without having dialysis be their life, only a treatment so they can live their life.

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