Disclosure

• Consultant: DaVita
Outline

• Review PD principles
• Review clinical applications
• Monitor adequacy
• Adjust prescription of patient with failing Kt/V
What should an ideal dialysis prescription include?

- Adequate solute removal
  - Urea
  - Middle molecules
  - Phosphate
  - Electrolytes

- Adequate fluid removal
  - Minimize glucose exposure
  - Diuretics

- Clinical assessment of patient governs change in prescription
  - Sense of well being
  - Blood pressure control
  - Nutritional status

- Minimize burden and maximize benefit
PD Principles: Transport characteristics

**Solute Removal**
- More rapid transporters saturate dialysate quickly and easily clear solute

**Fluid Removal**
- Glucose gradient drives fluid removal. More rapid transporters lose gradient quicker and remove less fluid over time
PD Principles: Urea Kinetics

After 4-6 hours dialysate urea saturation does not increase
Early saturation is more rapid
PD Principles: Transport of non-urea solute:
Some solutes saturate slowly.
After 4-6 hours urea removal may not increase but other solutes will!

To remove middle molecule need longer contact time
PD Principles:
Maximizing small versus middle molecule clearance

Figure 1 – A comparison of peritoneal clearances of creatinine (light bars) and $\beta_2$-microglobulin (B2M; dark bars) with different numbers of peritoneal dialysis (PD) exchanges over 24 hours in incremental PD. The clearance of creatinine increased almost linearly with the increasing number of exchanges (*$p < 0.05$), but the clearance of B2M was not different among the patient groups.

Figure 4 – A comparison of peritoneal clearances of creatinine (light bars) and $\beta_2$-microglobulin (B2M; dark bars) in 8 patients with 2 peritoneal dialysis (PD) exchanges over a period of 12 hours and 24 hours per day. Creatinine clearance was almost the same whether the patients performed 2 exchanges of PD over a period of 12 hours or over 24 hours per day. In contrast, the clearance of B2M almost doubled (*$p < 0.05$).
PD Principles:
UF Profile in High Transporters Dextrose vs Icodextrin

PD Principles: Three Pore Model

Interstitium

50% osmotic UF + Na-sieving during hypertonic dwell

Small Solutes

50% osmotic UF + small solute transport

Capillary lumen

Aquaporin (semipermeable membrane)

Dense intercellular fibers restrict transport

Loose intercellular fibers permit transport of macromolecules

Small solute + protein loss

Protein

Glycocalyx
PD Principles: Na Sieving
Gomes et al NDT 24:3513, 2009

Fig. 2. D/P sodium in the 2.27% and 3.86% PET (P < 0.001, at any point beyond 0 min).

Courtesy Dr. T. Golper
Sodium Sieving and Icodextrin

Lack of Na sieving with Icodextrin implies UF through Na permeable “pore”

Ho-dac-Pannekeet et al, KI, 1996
How do we measure PD Kt/V?

K = Clearance

\( t = \) time

\( V = \) Volume of distribution of Urea (TBW)

\[ K = \frac{(UV)}{P} \]

**Peritoneal Dialysis**

\[ K = \frac{\text{Dialysate urea} \times \text{Drain volume}}{\text{Plasma urea}} \]

Weekly \( K_t/V_{\text{urea}} \) =

\[ \frac{(D/P_{\text{urea}})(\text{Dialysate drain volume/day})(7 \text{ days})}{V_D \text{Urea (TBW)}} \]

\( D/P_{\text{urea}} \) is percent saturation and is determined by dwell time
How do we adjust PD Kt/V

Peritoneal Dialysis

\[
\frac{Kt}{V} = \frac{(D/P_{\text{urea}})(\text{Dialysate drain volume})}{V_D \text{Urea (TBW)}}
\]

\( \frac{Kt}{V} \) is percent saturation and is determined by dwell time

How do you increase Kt/V?

- Can’t change \( V_D \text{Urea (TBW)} \)
- Focus on Kt or the dialysis dose
- We can increase Kt by an increase in saturation of dialysate volume or increase in dialysate volume or both.
Relationship Between Time, Transport Type & Clearance

\[
\text{D/P} \times \text{X} \quad \text{DV} = \quad \text{DV/P} = \text{clearance}
\]

D/P Creatinine

Total Dialysate V

CrCL/exchange

- **H Transport**
- **L Transport**
How do we adjust PD Kt/V

Peritoneal Dialysis

\[
\frac{Kt}{V} = \frac{(D/P_{urea})(\text{Dialysate drain volume})}{V_D \text{ Urea (TBW)}}
\]

**Variables**

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

**Fixed**

- $V_D$

$D/P_{urea}$ is percent saturation and is determined by dwell time

Optimize dwell time
Exchange time ≠ dwell time
“Typical” CAPD Prescription

2.5 – 3.0 L

10 PM 6 AM 10 PM

2.5 L 2.5L 2.5 L

Noon 6 PM

Dwell times > 4 hours

2.5 L (Icodextrin)
“Typical” Cycler Prescription

2.0 – 2.5 L

2 - 2.5L Icodextrin
“Typical” Cycler Prescription

2 - 2.5L Icodextrin
Impact of fill and drain time on dwell time

Slide courtesy of Dr S. Mujais
Optimize dwell time

• Lost dwell time
  – Lost clearance
  – Lost ultrafiltration

• Monitor for poor catheter flow
  – Poor catheter flow increases infusion/drain time and shortens dwell time

• Do not add exchanges to cycler PD without increasing therapy time
Cycle Frequency and Dwell Time

Dwell Time (minutes/cycle) vs Number of Cycles for different cycle times:
- 9 hrs
- 8 hrs
- 7 hrs
How do we adjust PD Kt/V

Peritoneal Dialysis

\[
\frac{Kt}{V} = \frac{(D/P_{urea}) (\text{Dialysate drain volume})}{V_D \text{Urea (TBW)}}
\]

Variables

Fixed

D/P_{urea} is percent saturation and is determined by dwell time

Optimize exchange volume
Increase volume at night.
Intraperitoneal volume increases during exchange.
Monitor adequacy

- Clinical assessment of patient governs change in prescription
  - Sense of well being - monthly
  - Blood pressure control - weekly
  - Nutritional status – monthly
  - Kt/V – every 90 days
    - Includes PD and residual renal function
      - If patient is not anuric need to monitor for loss of urine output
Case #1

• 69 year old M with ESRD on PD for approximately 10 months coming in for monthly visit
• Diabetes, hypertension
• Has significant residual renal function (RRF)
• Current Rx- 4 Cycles – 4 cycles overnight with 2400 cc, 1 hour 30 min dwell time
  – Dry day
• Subjectively feels well, energy and appetite good
• Blood sugars mildly elevated
Case #1 Kt/V

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<tr>
<th>Wk Ending 08/06</th>
<th>Wk Ending 07/30</th>
<th>Wk Ending 07/23</th>
<th>Wk Ending 07/16</th>
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*Home Meds Start Depends*
Results: Total Kt/V
(Randomized control trial – 3 target Kt/V groups)

Renal Kt/V

Peritoneal Kt/V

How accurate is measurement of RRF?

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<td><strong>Coefficient of Variation (%)</strong></td>
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1) Weekly Kt/V is calculated based on a single day collection
2) Coefficient of Variation of residual Kt/V is much greater than PD Kt/V.
3) Contribution of RRF to total Kt/V should be discounted to assure than minimum Kt/V is achieved daily. Acknowledge that this might provide “overdialysis”.

Case #1 - Kt/V

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<tr>
<th>Analysis Adequacy</th>
<th>Wk Ending 08/06</th>
<th>Wk Ending 07/30</th>
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*Home Meds*

- Start: DC
Case#1 - solution

• Increase exchange volume?
  – Will increase urea clearance but not middle molecule removal

• Increase exchanges?
  – On cycler: Increase 4 to 5 exchanges?
  – Will need to be on PD longer = BURDEN
    • Will have minimal impact on middle molecule

• Needs day time fluid – last fill
  – Avoid high volumes during the day

• Minimize glucose exposure
  – Icodextrin
Questions?