Volume Management in Peritoneal Dialysis

How Can The Dietician Help?

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1. Why Does Volume Management Matter?
2. Recognizing Volume Status
3. Understanding Ultra-filtration
4. Tools for Managing Volume

The Importance of Volume Overload In PD Has Been Underappreciated

Daily Therapy “should work better” then intermittent therapy

Volume Overload Is strongly Associated With Mortality In Hemodialysis

- Large fluid gains associated with increased rate of cardiomyopathy, heart failure, and death
- Patients on HD more likely to die after weekend then on other days
- Patients on HD are more likely to be admitted to the hospital for CHF then patients on PD

Most Large Studies Have Shown Better 2 Year Survival In New Dialysis Patients Who Start PD Rather Then HD

- USRDS (USA)
- Netherlands Cooperate Study
- Canada National Database
- Danish National Database

But, Some Studies Have Suggested That Volume Overload is a Bigger Problem in PD then HD

- **Choice Study**- Large multi-center study from 2005.
- PD patients with cardiovascular disease had higher rates of mortality at 2 years then PD patients

Perhaps unrecognized volume overload in poorly managed PD patients is the real culprit???
Most Studies have shown poorer survival in high transport patients

- Other studies have suggested that patients who ultrafilter less than 750cc (or 1000cc) per day have increased mortality

- Anuric patients have mortality rates that are much higher than in patients with significant RRF

Managing Fluid Balance in PD Patients Should Be Easy

1. Identify Optimal Body weight for each patient
2. Control the amount of fluid that goes in
3. Adjust and control the amount of fluid that comes out

What is the Dry weight??

- Chest Xrays, echocardiograms, Electrical Bioimpedance, Inferior venocaval diameter,
- Natriuretic peptide levels (BNP) – largely useless

Blood pressure is optimally controlled with minimal use of medications, and with no meaningful orthostatic hypotension

Peripheral edema is minimized

Patients Rarely know Their Dry Weight, And It is Often Wrong

- Target weight set during training and not adjusted
- Target weight often determined by patient
- Patients often don’t keep their log books and weight isn’t followed
- Efforts to avoid hypertonic saline may undermine adequate fluid removal
- Fluid overload often only identified when extreme SOB, edema

Important Point
You and the Patient Should Know The Patient’s Dry Weight!

- Does each of your patients have an established dry weight?
- Does each of your patients know what his/her dry weight is Supposed to be?
- Does that dry weight get reevaluated every month?
Assessing Fluid Status

Correct Dry Weight should be reassessed every month

- True Weight loss—hospitalization, malnutrition, illness
- True Weight gain—usually occurs after PD initiated
- False weight gain—due to fluid retention

Different Patients Reveal Volume Overload Differently

<table>
<thead>
<tr>
<th>Healthy patients with normal albumin</th>
<th>Less Healthy patients with low albumin</th>
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<tbody>
<tr>
<td>Increased weight</td>
<td>Increased weight</td>
</tr>
<tr>
<td>Increased BP</td>
<td>Ankle edema</td>
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<tr>
<td>Sometimes ankle edema</td>
<td>Chest congestion</td>
</tr>
<tr>
<td>Chest congestion (rare)</td>
<td>Sometimes Increased BP</td>
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Malnourished Patients Can Be Under-dialyzed Despite Normal KT/V

If a malnourished patient loses weight (perhaps due to under dialysis), KT/V may be overestimated due to the fall in V

\[
\frac{KT}{V} = \frac{12 \times 0.95 \times 7}{80 \times 0.6} = 1.66
\]

80 kg man with 12 liters of exchange per day and D/P urea of 0.95

What if patient loses 10 kg in lean body wt?

\[
\frac{KT}{V} = \frac{12 \times 0.95 \times 7}{70 \times 0.6} = 1.9
\]

On the Other Hand…. 

Obese patients, or patients who have KT/V calculated while volume overloaded, will have an inflated V

And, KT/V may be measured as artificially low

Excess Body Fluid Volume Also Lowers Serum Albumin Levels

- This is a dilutional effect that probably does not reflect nutritional status

Besides lowering your DQI score and hurting your dietician’s reputation, does this matter?
Low Albumin and Low KT/V Both Predict Higher Mortality

Perhaps the correlation between low Albumin and KT/V with poor survival is partly due to the effects of excessive body fluid???

Hypovolemia is PD

- Low BP
- Leg cramps, lightheadedness, presyncope
- Nausea, weakness

Hypovolemia- Reasons

- Too much hypertonic dextrose or Icodextrin
- Inadequate fluid intake
- Uncontrollable fluid losses (diarrhea)
- Real weight gain without adjustment in DW

Hypovolemia In PD- Solutions

- Use lower osmolality dialysate
- (1.5% rather than 4.25%)
- Increased fluid intake
- Increased salt intake
- Reduce Antihypertensive medications

- Always consider other possibilities (GI bleed, sepsis, heart failure)

Hypervolemia- 3 Possible Reasons

1) New or worsening disease state
   - cardiac failure
   - hypoalbuminemia
   - use of drugs that cause fluid retention (minoxidil, actos, avandia)
2) Too much fluid going in
3) Not enough fluid coming out

Dietary Non-compliance

how can you tell?

The average daily total of urine plus ultrafiltration volume should equal the daily fluid intake

\[ \text{U.O.} + \text{U.F.} = \text{Fluid Intake} \]
**Important Point**
Controlling Salt and Fluid Intake in PD Is Just as Important as in HD!

- Are you reviewing the patient flow sheets every month?
- Do you understand how to look at the quarterly kinetics to assess fluid intake?
- Is volume intake being addressed first when fluid overload becomes an issue?
- Compliant patients take in <1500 cc per day

**How Can You Get Patients To Drink Less?**

- Limit their salt intake
- Terrorize them with pictures of ventilator machines and endotracheal tubes
- Drink fluids only with meals and meds
- Ice chips, gum, etc.

**Volume Management—How does the fluid get out?**

- Urine Output (RRF)
- Fluid removed with dialysis, based on the number of PD exchanges, and the amount of volume that is removed with each exchange

**Important Point**
Diuretics Should Be Used In PD Patients Who Have RRF

- Diuretics increase daily urine output
- Diuretics do not affect RRF
- Diuretics do cause hypokalemia
- Diuretics may reduce the number of PD exchanges needed each day, and definitely reduce the need for hypertonic exchanges

**Effect of Lasix on Urine Output in New CAPD patients**

Kidney Int 2001 59(3) 1128-33

**Fluid Overload Can Be Due to Loss Of Residual Renal Function**

Rottembourg J, Kidn Int S 1993 40:S106
How Can You Tell If Patient Is Losing Residual Renal Function?

1) Patients rarely record urine output, but they can tell when they make less
2) Pay special attention after hospitalizations and episodes of peritonitis
3) Measure quarterly kinetics and monitor urine output and residual KT/V

Hypervolemia- Causes

1) Excessive fluid intake (>1500 cc/d)
2) Suboptimal urine output or loss of RRF
3) Suboptimal fluid removal with peritoneal dialysis exchanges

What Are the Factors That Allow for Peritoneal Ultra-filtration?

1) A semi-permeable Peritoneal Membrane with adequate function/surface area
2) Osmotic Gradient- water diffuses from the blood into the peritoneum
3) Lymphatic re-absorption of fluid back into systemic circulation limits ultra-filtration

Molecules diffuse down their concentration gradient when they can

Over time, movement of water (into) and glucose (out of) the peritoneal cavity reduces these concentration gradients, and transport slows or even stops

- In the meantime, the lymphatic system gradually removes fluid from the peritoneum and returns it to the systemic circulation
- Given enough time, most fluid in the abdomen will gradually be reabsorbed

What Happens to Fluid that is Infused into the Abdomen?

1) UF is maximal at the start of the dwell (15 cc/min), depending on PET
2) UF rate falls as glucose diffuses out of abdomen and UF dilutes glucose, lowering concentration gradient
3) After 3-6 hours, net fluid adsorption by peritoneum occurs
The Rate At Which Fluid Moves Into the Abdomen From The Blood Stream Depends Upon

- Osmotic Gradient
- Membrane characteristics
  - vascular and porous: high transporter
  - less vascular and less porous: low transporter

Can Diabetes Affect Ultrafiltration?

- Normal serum osmolarity = 270 mOsm/L
  - Dextrose Dialysate mOsm/L
    - 1.5%: 345
    - 2.5%: 395
    - 4.25%: 484

If blood glucose is 540 mg/dL, serum osmolality is elevated (320 mosm/L). This limits the osmotic gradient and reduces ultrafiltration.

But Volume is More Likely To Affect Diabetes

- Excessive fluid intake: Volume retention
- More 4.25% exchanges: More hyperglycemia
- Poorer UF

Better volume control in diabetes improves diabetes control!

Important Point

- Better Volume Control in PD Improves Diabetes Control!
- Limiting salt and water intake reduces need for hypertonic dextrose, reducing caloric intake, hyperglycemia, and weight gain!

Peritoneal Equilibration Test

- Every PD patient has a PET done to characterize their membrane transport characteristics
- A PET measures the ratio of Creatinine in the dialysate compared with the blood after a 4 hour dwell (D/P Creatinine)
- The larger, more vascular and porous the membrane, the faster water, glucose and creatine will travel across it
**How Does knowing The PET Help?**

- **High (Rapid) Transporters** move water (and solutes) quickly across the membrane. They do better with short dwell times and usually require higher dextrose concentrations.
- **Low transporters** move water more slowly. Longer dwell times work well, and lower dextrose concentrations are usually adequate.

**Factors Affecting Fluid Balance**

*Appropriate Prescription*

Impact of Dwell Time on Ultrafiltration
Comparison Between a Low Transporter and a High Transporter

**Net UF and Dialysate**

**Dry Days May Be Better**

- Do not be afraid to have high transport patients go dry during the day, especially if they have significant residual renal function.
  - limits glucose exposure
  - avoids daytime fluid adsorption
  - improves patient satisfaction

**Hypertonic Dextrose Is Often Necessary In High Transport Patients**

Don’t let worries about the long term consequences of hypertonic dextrose prevent the short term goal of proper volume management!
Hypertonic Dextrose is Necessary In High Transport Patients- Should We Worry?

- More calories- definitely
- Hyperglycemia in diabetics- certainly
- More weight gain- frequently
- Long term injury to the membrane- maybe

Extraneal

- Extraneal (Icodextrin) is a glucose polymer that is adsorbed more slowly from the peritoneum then is dextrose, such that enhanced ultra filtration over time can occur.

Slower Adsorption from the abdomen allows Extraneal to maintain an osmotic gradient for 8-16 hours

- This is clinically relevant for high and high average transporters (PET >0.65)
- Minimal advantages for low/low average transporters, or for dwell times <8 hours

Other Advantages to Extraneal

- Minor improvements in KT/V, mainly due to additional convective solute clearance
- Reduction in daily caloric intake compared with 4.25% dextrose
- Probably benefit regarding weight gain in some patients

Doubts About Extraneal

- No clear data showing improved diabetes control
- No clear human data showing benefit in long term membrane function preservation
- No benefit in preserving RRF
- No established benefit in low or low-average transporters

Caloric Adsorption with PD

<table>
<thead>
<tr>
<th></th>
<th>1.5% Dextrose</th>
<th>2.5% Dextrose</th>
<th>4.25% Dextrose</th>
<th>7.5% Icodextrin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbs Adsorbed (g)</td>
<td>15-22</td>
<td>25-45</td>
<td>45-75</td>
<td>20-40</td>
</tr>
<tr>
<td>KCal Adsorbed (Kcal)</td>
<td>+/- 105</td>
<td>+/- 172</td>
<td>+/- 292</td>
<td>+/- 150</td>
</tr>
</tbody>
</table>

IP Dextrose Adsorption accounts for approximately 25% of daily calories 100-300 grams per day

Adapted from Dr John Burkhart
Problems With Extraneal

- Rash or Itching - 3-5%
- False readings on glucometer due to maltose adsorption
- Clinics sometimes use it as a way of managing noncompliant patients on suboptimal dialysis and medication regimens
- No benefit in Type 2 membrane failure
- Very expensive

The PD Prescription

- PET results, body size, and knowledge about RRF help to determine optimal prescription
- Number and volume of exchanges, dwell times and dialysate concentration will determine ultrafiltration volume for any given patient

Dietician- What do You Need To Know?

1) Monitor fluid intake, and both urine/ultrafiltration volumes
2) Recognize volume mismanagement
3) Understand the basics of ultrafiltration principles, and how a PD prescription works
4) Manage and intervene when necessary to protect pt from dehydration and fluid overload

THE END

QUESTIONS????

And Always remember……

PD Is Better!