Disclosures statement:

- Consultant: Allena, Becker Professional Education
- Grant support: Sanofi-Aventis
- Speaker honoraria: Sanofi-Aventis

Objectives

- To discuss evaluation of hypervolemia in peritoneal dialysis patients
- To review prevention and treatment of hypervolemia in peritoneal dialysis patients
Peritoneal dialysis: ultrafiltration basics

Peritoneal membrane barrier


Three-pore model of peritoneal transport

Effect of aquaporin-1 (AQP1) deletion on the transport of water across the peritoneal membrane


Endothelial barrier to water transport during peritoneal dialysis


Peritoneal dialysis: hypertension and heart failure epidemiology
Hypertension: prevalence in peritoneal dialysis patients and association with GFR

Fluid retention in PD patients

Symptomatic fluid retention in 1 out of every 4 PD patients:

- Lower extremity edema 98.6%
- Pleural effusions 76.1%
- Pulmonary congestion 80.3%

Mean arterial pressure over time from initiation of peritoneal dialysis.
Mean antihypertensive use over time from initiation of peritoneal dialysis.

Residual renal function over time from initiation of peritoneal dialysis.

Event rates of cardiovascular diagnoses & procedures, by modality, 2009–2011
Heart failure in prevalent dialysis patients, by modality, 2011

USRDS, 2013 ADR

Prevalence of left ventricular hypertrophy (a), and relative frequency of the concentric and eccentric pattern (b) in CAPD and in HD patients


Three-year patient survival rates in PD patients according to total fluid removal. The four groups are defined as: group I, <1265 mL/24 h/1.73 m²; group II, 1265 to 1570 mL/24 h/1.73 m²; group III, 1570 to 2035 mL/24 h/1.73 m²; and group IV, >2035 mL/24 h/1.73 m².

Peritoneal dialysis: causes and evaluation of volume overload

Volume overload in PD patients is preventable

Too much in
- Adherence with salt and fluid intake
- PD prescription: adequate osmotic stimulus

Too little out
- Loss of residual renal function
- PD prescription: adequate osmotic stimulus
- Peritoneal membrane failure

Co-morbidity
- New or worsening heart disease
- Hypoalbuminemia
- Mechanical problem

Target weight?

Residual renal function over time from initiation of peritoneal dialysis.

Polydipsia in PD patients?

Thirst profiles for control and PD. Profiles show mean thirst score for each group at each time point±SEM.
Under-reporting of water intake by PD patients?

Box and whisker plot showing calculated fluid balance.


Improvement in BP with salt and fluid restriction in PD


CAPD patients with diabetes are more fluid overloaded than non-diabetic patients

Fluid status improvement in diabetic CAPD patients after dietary salt and fluid restriction


- Empty bars, before dietary restriction
- Black bars, after dietary restriction

Sodium removal in APD is lower than in CAPD


PD catheter mal-position

2 liter fill and drain test

- Inflow difficulty
- Fibrin clot
- Incomplete drainage
- Positional drainage

PD: mechanical complications

<table>
<thead>
<tr>
<th>Problem</th>
<th>Details</th>
<th>Management considerations</th>
</tr>
</thead>
</table>
| Leaks          | Typically seen early after catheter placement                           | - Reduce fill volume and intraperitoneal pressure  
                 |                                                                         | - Can accomplish this with bed rest                                                      |
| Inflow problem | Pain can result from low pH of PD solution or from peritonitis          | - Test for peritonitis  
                 |                                                                         | - Can slow infusion rate, add bicarbonate or lidocaine to bag                           |
| Outflow problem| From clots, fibrin, or constipation                                    | - Treat constipation  
                 |                                                                         | - Leaving fluid incompletely drained after prior dwell reduces outflow pain            |
| Pleural effusion| From congenital or acquired defects in diaphragm, more common on right side, in women, and in PKD patients | - Diagnose by testing glucose on pleural fluid and or with radio labeled albumin or methylene blue  
                 |                                                                         | - Treat with PD holiday, VATS, or open surgery                                        |
                 |                                                                         | - Can suffer from under-dialysis  
                 |                                                                         | - Must achieve drain volume > 9 L/24 hrs                                              |

Peritoneal Equilibration Testing

<table>
<thead>
<tr>
<th>Type</th>
<th>Frequency, %</th>
<th>D/P Creatinine at 4 hours</th>
<th>Comments</th>
</tr>
</thead>
</table>
| High          | 10           | 0.82-1.03                 | - Best managed with cycler  
                 |                                                                         | - Can experience “UF” failure  
                 |                                                                         | - Albumin often low                                                      |
| High Average  | > 50         | 0.65-0.81                 | - Can be managed with CAPD or cycler-7.5 to 9 L/24 hrs                    |
| Low Average   | > 30         | 0.50-0.64                 | - Standard PD high dose needed for larger patients                        |
| Low           | 5            | 0.34-0.49                 | - Manage with long dwell CAPD  
                 |                                                                         | - Can suffer from underdialysis  
                 |                                                                         | - Must achieve drain volume > 9 L/24 hrs                                  |
Peritoneal dialysis: monitoring and prevention of volume overload

Monitoring for volume overload

- Active surveillance
- Monthly review of PD prescription
- Urine volume measurement on every 1-2 month basis
- Overnight drain volume review in CAPD patients
- Day time drain volume review in APD patients
- PET testing as indicated
Potential areas of intervention

- Dietary salt and fluid intake
- Residual renal function
  - Diuretics
  - Avoid nephrotoxic agents
  - Angiotensin inhibition
  - Control of HTN
  - Treatment of urinary obstruction
- Adherence to PD prescription
- PD catheter function
- Matching dwell time to transport type


**Diuretics in PD**

Evolution of urine volume (UV) over one year of peritoneal dialysis (PD). UV at randomization was comparable between groups. In the diuretic group (●), it remained constant over one year of CAPD, whereas in the control group (+), UV declined. Data presented are mean SEM at each time point.


**Long dwell UF**

Short dwell UF


Net drained UF volume (ml) during a 15 h long dwell with 3.86% glucose (black bars), 7.5% icodextrin (gray bars), or a mix of 6.8% icodextrin and 2.6% glucose (white bars) (n=7).


Net Na+ removal during a 15 h long dwell with 3.86% glucose (black bars), 7.5% icodextrin (gray bars), or a mix of 6.8% icodextrin and 2.6% glucose (white bars) (n=7).

Summary

• Evaluating and managing volume is critical part of PD management
• Focus should be on prevention and early detection of volume overload in PD patients
• Treatment options for impaired ultrafiltration
  – dwell time shortening
  – frequent hypertonic exchanges
  – icodextrin
  – use of diuretics in patients with residual renal function

Acknowledgements

• MGH CAPD Unit
Fluid Overload vs UF Failure

An Important Distinction

- Fluid overload is a common clinical syndrome with multiple causes
- It is the inability to maintain target weight and oedema free state
- UF failure is a pathophysiologic characterisation of one of the causes of the clinical syndrome
- Distinction between syndrome and cause determines the intervention to be taken