Peritoneal Dialysis for Acute Kidney Injury

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Outline

- Overview of global variation in the use of peritoneal dialysis for acute kidney injury
- Overview of potential advantages of acute peritoneal dialysis
- Overview of concerns resulting in underutilization of acute peritoneal dialysis
- Review of outcome data on acute peritoneal dialysis
- Review of acute peritoneal dialysis in refractory heart failure
Worldwide Epidemiology of AKI

Lancet 2015;385:2616-2643
Epidemiology of Acute Peritoneal Dialysis Data

- Geographic distribution of studies describing outcomes in AKI treated with PD
  - Only 5 studies from high income areas
  - Most data published after 2000

### Advantages and Disadvantages

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technically simple</td>
<td>Contraindicated in recent abdominal surgery</td>
</tr>
<tr>
<td>Less infrastructure</td>
<td>Requires intact peritoneal cavity</td>
</tr>
<tr>
<td>Cost effective</td>
<td>May not be effective in severe acute pulmonary edema / hyperkalemia</td>
</tr>
<tr>
<td>Avoids vascular access</td>
<td>Peritonitis can occur</td>
</tr>
<tr>
<td>Biocompatible</td>
<td>Clearance and ultrafiltration unpredictable</td>
</tr>
<tr>
<td>Continuous renal replacement therapy</td>
<td>Concerns for hyperglycemia</td>
</tr>
<tr>
<td>Hemodynamic stability</td>
<td>Concerns for impaired respiratory mechanics</td>
</tr>
<tr>
<td>Gradual solute removal</td>
<td>Concerns for protein loss</td>
</tr>
</tbody>
</table>

Semin Nephrol 2017;37(1):103-113
Several questions have been raised

• Is there a mortality difference between acute PD and extracorporeal therapies?
• Is there a difference in renal recovery between modalities?
• What should be the prescribed dialysis dose?
• Are infection rates different?
• Cost and economic implications
Acute PD in Critical Illness

**HEMOFILTRATION AND PERITONEAL DIALYSIS IN INFECTION-ASSOCIATED ACUTE RENAL FAILURE IN VIETNAM**

- RCT to assess efficacy and safety of acute PD in patients with either severe falciparum malaria or sepsis
- Comparison of continuous venovenous hemofiltration and manual acute PD
- Terminated early due to high mortality (47%) in PD patients (p<0.005)
- Several caveats
  - Use of rigid catheters, increasing risks of leaks
  - Manual exchanges with open drainage system
  - High rate of culture negative peritonitis

Acute PD in Critical Illness

RCT of CVVHDF (n=25) vs continuous manual PD (n=25)

Similar mortality rates in both groups; 84% vs 72%

No difference in composite correction of metabolic parameters
  • Improved correction of acidosis in PD group
  • Faster correction of fluid overload in CVVHDF group

Perit Dial Int 2011;31(4):422-429
Acute PD in Critical Illness

• RCT investigating outcomes of continuous tidal PD (n=63) vs CVVHDF (n=62)
• Improved survival in tidal PD group (69.8% vs 46.8%, p<0.01)
• Improved metabolic control in PD arm
• Shorter duration of ICU stay in PD arm

Ther Apher Dial 2018;22(4):371-379
High Volume PD vs Daily Hemodialysis

Patients randomized to receive high volume PD (n=60) vs daily dialysis (n=60)

- Prescribed $Kt/V$ 0.65 per day (HVPD) and 1.2 per session (HD)
- CCPD with 35-50 min dwell volume, 7 days a week
- Daily HD sessions, 6 days per week
- Higher delivered $Kt/V$ in HD group

Kidney International 2008;73:S87-S93
High Volume PD vs Daily Hemodialysis

Similar overall mortality rates (58% vs 53%, p=0.48)

Similar outcomes in metabolic control
Stabilization of metabolic parameters after same number of dialysis sessions

Kidney International 2008;73:S87-S93
High Volume PD vs Extended Daily Hemodialysis

- Patients randomized to receive high volume PD (n=61) vs extended daily dialysis (n=82)
- Patients in the HD group had higher ultrafiltration and faster metabolic control
- Similar overall mortality (63.9% vs 63.4%, p=0.94)

Int Urol Nephrol 2013;45:869-878
Impact on Renal Recovery

• Few studies have reported rates and time to renal recovery

- Improved recovery of kidney function in PD arm, as well as shortened time for AKI resolution

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Group A $N = 62$</th>
<th>Group B $N = 63$</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious complications related to dialysis, $N$ (%)</td>
<td>11 (17.7)</td>
<td>6 (9.5)</td>
<td>0.0084</td>
</tr>
<tr>
<td>Time to prepare dialysis access and initiate dialysis, (min), median (IQR)</td>
<td>35 (30-37)</td>
<td>38 (32-40)</td>
<td>0.2010</td>
</tr>
<tr>
<td>Recovery of kidney function, $N$ (%)</td>
<td>22 (35.5)</td>
<td>38 (60.3)</td>
<td>0.0056</td>
</tr>
<tr>
<td>Resolution of AKI (days), median (IQR)</td>
<td>8 (7-10)</td>
<td>5 (4-6)</td>
<td>0.0044</td>
</tr>
<tr>
<td>ICU stay (days), median (IQR)</td>
<td>19 (13-20)</td>
<td>9 (7-11)</td>
<td>0.0031</td>
</tr>
<tr>
<td>Need of chronic dialysis, $N$ (%)</td>
<td>7 (11.3)</td>
<td>6 (9.5)</td>
<td>0.3112</td>
</tr>
<tr>
<td>Mortality, $N$ (%)</td>
<td>33 (53.2)</td>
<td>19 (30.2)</td>
<td>0.0028</td>
</tr>
</tbody>
</table>

Ther Apher Dial 2018;22(4):371-379
Impact on Renal Recovery

• Similar rates of renal recovery, shorter time to renal recovery

<table>
<thead>
<tr>
<th></th>
<th>HVPD (n=60)</th>
<th>DHD (n=60)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality (%)</td>
<td>58</td>
<td>53</td>
<td>0.48</td>
</tr>
<tr>
<td>Recovery of kidney function (%)</td>
<td>83</td>
<td>77</td>
<td>0.84</td>
</tr>
<tr>
<td>Duration of treatment (days)</td>
<td>5.5 ± 2.7</td>
<td>7.5 ± 3.1</td>
<td>0.02</td>
</tr>
<tr>
<td>Resolution of AKI (days)</td>
<td>7.2 ± 2.6</td>
<td>10.6 ± 4.7</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Kidney International 2008;73:S87-S93
Impact on Renal Recovery

- No difference in recovery or time to AKI resolution

### A randomized clinical trial of high volume peritoneal dialysis versus extended daily hemodialysis for acute kidney injury patients

<table>
<thead>
<tr>
<th></th>
<th>EHD</th>
<th>HVPD</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality (%)</td>
<td>63.4</td>
<td>63.9</td>
<td>0.94</td>
</tr>
<tr>
<td>Recovery of kidney function (%)</td>
<td>26.9</td>
<td>29.6</td>
<td>0.11</td>
</tr>
<tr>
<td>Resolution of AKI (days)</td>
<td>11 (5.7–20)</td>
<td>9 (5.7–19)</td>
<td>0.58</td>
</tr>
<tr>
<td>Need for chronic dialysis (%)</td>
<td>9.7</td>
<td>6.5</td>
<td>0.23</td>
</tr>
<tr>
<td>Infectious complications related to dialysis method (%)</td>
<td>19.5</td>
<td>16.3</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Int Urol Nephrol 2013;45:869-878
Dose of Dialysis

• Appropriate dose for acute PD is poorly defined
• Studies have reported similar outcomes compared to hemodialysis with delivered $K_t/V$ of 3.6
• Both studies used CCPD with 35-50 min dwell time
• 36-44 liters and 18-22 exchanges per day

Kidney International 2008; 73:S87-S93
Int Urol Nephrol 2013; 45:869-878
Higher vs Lower Intensity High-Volume PD

• Only 1 RCT has investigated effect of PD dose on outcomes in AKI
  • 30 patients in high intensity PD (0.8 per session), 31 patients in low intensity (0.5 per session)
  • Delivered doses 0.59 per session and 0.49 per session respectively (p=0.03)
  • Similar mortality rate in both groups
  • Similar rates of renal recovery and time on dialysis

• ISPD guidelines recommend targeting a weekly Kt/V > 2.1
  • 2 liter dwell volume, 2 hour dwell time
  • Approximately 24 liters CAPD per day

Adv Perit Dial 2011;27:118-124
Perit Dial Int 2014; 34(5):494-517
Infectious and Mechanical Complications

• Few studies have reported rates of infectious and mechanical complications, and data has been inconsistent
  • High rates of culture negative peritonitis reported in study using open drainage system
  • Similar rates of peritonitis in high intensity PD vs low intensity PD

Adv Perit Dial 2011;27:118-124
Infectious and Mechanical Complications

• Similar rates of peritonitis and blood stream infections in study comparing acute PD to daily hemodialysis, and extended daily hemodialysis

• Decreased rates of catheter infections and catheter change in tidal PD group vs CVVHDF

Kidney International 2008;73:S87-S93
Int Urol Nephrol 2013;45:869-878
Ther Apher Dial 2018;22(4):371-379
Cost and Economic Implications

• Varying data available
  • Cost of hemodialysis equipment vs PD equipment; INR 5000 vs INR 250-300
  • Cost of CCVHDF vs PD disposables; INR 7184 ± 1436 vs INR 3009 ± 1643, p<0.01
  • Conflicting data from an earlier study; cost per PD survivor $ 6950 vs $ 2080 for CVVHF

Kidney Int 2002;61:747-757
Perit Dial Int 2011;31(4):422-429
Cost and Economic Implications

• Cost implications significant for lower income countries
  • Lower costs associated with local production of peritoneal fluid; varying dextrose percentages injected into bags of Lactated Ringer’s
  • Much higher costs associated with commercially available solutions
Peritoneal Ultrafiltration for Refractory Heart Failure

- Diuretic refractory heart failure results in a significant burden of hospital admissions
- High 6 month (>50%) and 1 year (74%) mortality rates
- Peritoneal ultrafiltration has been proposed as treatment of home-based management of refractory heart failure
- Studied in small prospective and cohort studies

Peritoneal Ultrafiltration for Refractory Heart Failure

- Varying regimens have been reported
  - Manual overnight exchange with single icodextrin dwell
  - 2 manual exchanges with overnight icodextrin dwell
  - Overnight automated PD 2-4 nights each week

- Several outcomes studied
  - NYHA functional status
  - Hospitalizations
  - Quality of life
  - Mortality
  - Echocardiographic parameters

Perit Dial Int 2014;34(1):64-70
Nephrol Dial Transplant 2010;25:605-610
Perit Dial Int 2014;34(1):100-108
Peritoneal Ultrafiltration for Refractory Heart Failure

• Largest retrospective cohort included 126 patients
  • Decreased body weight during first 3 months of PD initiation (p=0.04)
  • Improved LVEF during first year of therapy (38% ± 19% vs 42% ± 17%)
  • Reduction in HF related hospitalization (3.3 ± 2.6 vs 0.3 ± 0.5 days/month)
  • 1 year mortality 42%

• Similar changes in hospitalization days noted in other studies
  • 62 ± 16 vs 11 ± 5 days/patient/year
  • 43 ± 33 vs 11 ± 17 days/patient-year

Perit Dial Int 2014;34(1):64-70
Nephrol Dial Transplant 2010;25:605-610
Perit Dial Int 2014;34(1):100-108
Peritoneal Ultrafiltration for Refractory Heart Failure

- NYHA functional class
  - At 1 year, 85% of patients had reduction by at least 1 NYHA class

- Echocardiographic parameters
  - Increase in LVEF
  - Decreased pulmonary artery systolic pressures

Perit Dial Int 2014;34(1):64-70
Conclusion

- Very few RCTs have compared acute PD with extracorporeal therapies
- Currently, all analyzed RCTs have been conducted in Brazil and India
- Sample sizes in these studies are <100 patients per group
- Varying methods and prescriptions of acute PD
Acute PD Prescription

• Ideally, flexible tunneled Tenckhoff catheter to be inserted
  • Rigid catheter/drainage tubes in resource scarce areas
• Closed system of fluid delivery and drainage
  • CCPD; reduces nursing time, can perform tidal PD
  • CAPD; ideal in resource poor settings

Perit Dial Int 2014;34(5):494-517
Acute PD Prescription

Acute PD

Flexible, cuffed PD catheter percutaneous/surgical insertion

Rigid catheter

Adequate resources

Shock or liver failure

Yes

No

Yes

Bicarbonate containing dialysate

Cycler: 36-44 litres with 2 litre fill volumes
Manual: 50kg - 1.5 litre 2 hourly cycles
50-80kg - 2 litre 2 hourly cycles
80kg - 2 litre 1.5 hourly cycles
Consider change to 4 hourly cycles once acidosis, pulmonary oedema and hyperkalaemia resolved

Standard dialysate

No

Standard dialysate

Target weekly Kt/V – 2.1
<40kg – 1 litre 2 hourly cycles
40-60Kg – 2 litre 3 hourly cycles
>60kg – 2 litre 2 hourly cycles
Change to 4 hourly cycles once acidosis, pulmonary oedema and hyperkalaemia resolved

Perit Dial Int 2014;34(5):494-517
Conclusion

• Marked heterogeneity in the current RCTs
• Several important outcome measures need to be investigated
  • Length of ICU stay, length of hospital stay
• Need standardized reporting of technique dose, complications and cost
Conclusion

• Current data suggests that acute peritoneal dialysis is an appropriate modality for renal replacement therapy
• No significant difference in outcomes compared to extracorporeal therapies
• Acute PD been recommended by the ISPD as a suitable method for renal replacement
• Peritoneal ultrafiltration has been shown to be a suitable option in patients with refractory heart failure

Perit Dial Int 2014;34(5):494-517
Future Direction

• Aim to have 0 preventable deaths from AKI by 2025
• Saving Young Lives program established in 2012
  • Establishing sustainable acute PD programs in low-resource settings

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<thead>
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<tbody>
<tr>
<td>Benin (Cotonou)</td>
<td>24</td>
</tr>
<tr>
<td>Cambodia (Phnom Penh)</td>
<td>3</td>
</tr>
<tr>
<td>Cameroon (Mbēngô)</td>
<td>27</td>
</tr>
<tr>
<td>Ethiopia (Addis Ababa)</td>
<td>3</td>
</tr>
<tr>
<td>Ghana (Accra)</td>
<td>8</td>
</tr>
<tr>
<td>Ghana (Kumasi)</td>
<td>80</td>
</tr>
<tr>
<td>Ivory Coast (Abidjan)</td>
<td>24</td>
</tr>
<tr>
<td>Tanzania (Moshi)</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>175</strong></td>
</tr>
</tbody>
</table>

Kidney Int 2016;89(2):254-256
Thank You

• Questions?