RRT modalities and selection

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What do we have?

CVVH
SLED
IHD
SCUF
CVVHD
PD
CVVHDF
IHDF
PIRRT

What do we have?

Mechanism of solute transport

CVVH
IHD
SCUF
SLED/PIRRT
CVVHD
CFPD
CVVHDF
IHDF
PD
What do we have?

Continuous vs intermittent vs hybrid

CVVH    IHD    SLED/PIRRT
SCUF    IHDF  
CVVHD    PD    
CVVHDF   
CFPD

Extracorporeal vs intracorporeal

CVVH    PD    
SCUF    IHDF  
CVVHDF   
IHD    CVVHD  
SLED/PIRRT

Mechanisms of solute transport

Combination = hemodiafiltration
Mechanisms of solute transport

Dialysate in
Dialysate out

Replacement in
Replacement out

Ultrafiltrate out

Predilution
Postdilution

Replacement in
Replacement in

Ultrafiltrate out
Ultrafiltrate out

Mechanisms of solute transport

Diffusion
Convection

Molecular weight

Water
Dialysate
Ultrafiltrate

Diffusion or convection?

Prospective randomized cross-over study - n=15 - CVVH vs CVVHD

Median filter life: CVVHD 37h (19.5-72.5) vs CVVH 19h (12.5-28) p 0.03

Kaplan-Meier analysis of circuit survival for continuous veno-venous haemofiltration (CVVH) and continuous vena-venous dialysis (CVVHD).


Diffusion or convection?

Prospective randomized cross-over study - n=15 - CVVH vs CVVHD

Relative change of plasma concentration

<table>
<thead>
<tr>
<th>Mediator</th>
<th>CVVH</th>
<th>CVVHD</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Patients (n=13)</td>
<td>Relative change of plasma concentration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TNF-α</td>
<td>0.87 ± 0.22</td>
<td>1.25 ± 0.51</td>
<td>0.021</td>
</tr>
<tr>
<td>IL-6</td>
<td>1.19 ± 0.51</td>
<td>1.57 ± 1.25</td>
<td>NS</td>
</tr>
<tr>
<td>IL-10</td>
<td>1.10 ± 0.28</td>
<td>1.31 ± 0.27</td>
<td>NS</td>
</tr>
<tr>
<td>sL-selectin</td>
<td>1.02 ± 0.12</td>
<td>0.99 ± 0.04</td>
<td>NS</td>
</tr>
<tr>
<td>Endotoxin</td>
<td>1.13 ± 0.43</td>
<td>1.19 ± 0.20</td>
<td>NS</td>
</tr>
</tbody>
</table>

Diffusion or convection?

Animal model of sepsis - CVVH vs CVVHD

Herrera et al. J Trauma Acute Care Surg 2012; 73: 855-60

- Feasibility pilot RCT - CVVH vs CVVHD with similar small solute clearance
  - AKI + hemodynamic instability
  - No difference in mortality (C 54% vs D 55%)
  - Dialysis dependence at 60d (C 24% vs D 19%)

Wold et al. Crit Care 2012; 16: R205

Diffusion or convection?

Practice patterns based on surveys

Friedrich et al. Crit Care 2012; 16: R146

- Internet: 54
- Aust: 34
- NZ: 269
- UK: 27
- US adults: 13
- US peds: 22
- Can: 22

Friedrich et al. Crit Care 2012; 16: R146
### Continuous or intermittent?

**early years**

IHD = standard treatment for AKI in the critically ill - hemodynamic intolerance is perceived as significant problem

1976-1980

CAVH discovered "by accident" and launched as alternative treatment for the hemodynamically unstable patients

1985 and following

Further refinement of CRRT with evolution to venovenous techniques and wide acceptance (satisfaction) by intensivists

### Advantages of CRRT vs IHD

- Gradual fluid removal
  - more hemodynamic stability → better renal recovery
  - easier control of fluid balance
- Gradual solute removal
  - no large fluid shifts - dysequilibrium - cerebral edema
  - more efficient solute removal (mobilisation from extra-plasmatic compartment)
- 24h → More flexibility
- Machines are user-friendly → ICU nurses
- Hypothermia beneficial in some patients

### Disadvantages of CRRT vs IHD

- Need for continuous anticoagulation
- Patient immobilisation
- Interruption for diagnostic and therapeutic procedures
- Less efficient when rapid removal of small toxins is required in life-threatening conditions
- Requirement for specific equipment
- Higher costs
What is the evidence: mortality?

3 meta-analyses of RCTs
OR/RR for mortality with CRRT vs IHD

Bagshaw (9RCTs) 0.99 (0.78-1.26)
Rabindranath (7RCTs) 1.01 (0.92-1.12)
Pannu (7RCTs) 1.10 (0.99-1.23)

What is the evidence: renal recovery?

3 meta-analyses of RCTs
OR/RR for renal recovery with CRRT vs IHD
(dialysis independence or GFR above 15ml/’at hospital discharge)

Bagshaw (4RCTs) 0.76 (0.28-2.07)
Rabindranath (3RCTs) 0.99 (0.92-1.07)
Pannu (5RCTs) 1.01 (0.92-1.09)

What is the evidence: hemodynamics?
Results generalizable?

4 academic centers
more than 4 years

-20 patients/center/year

Mahdta et al. Kidney Int 2001; 60: 1154-63

Results generalizable?

Selection: Serum creatinine > 2 mg/dL
Included n=1302

Patients excluded: no RRT n=652

Patients eligible in need for RRT n=650

Medical reasons: Coagulation disturbances or hemodynamic instability

47%

Lins et al. Nephrol Dial Transpl 2009; 24: 512-518

Results generalizable?

How many patients were eligible?

Mean = 5 patients /center/year

IHD=conventional dialysis
(mean 5.2h/day)

Not all IHD is equal

Measures to improve hemodynamic stability during IHD

- Increase duration
- Start without ultrafiltration and slowly increase
- Sequential dialysis and ultrafiltration
- Increase dialysate sodium
- Cool dialysate

The spectrum of RRT

Continuous RRT

Hybrid RRT

Optimized IHD

Conventional IHD

- SLED
- EDD
- PIRRT
- 6-16h/d conventional dialysis machines

Hybrid treatments

Prospective randomized study  n=332 surgical ICU + AKI
CVVH vs SLED (badge dialysis)

Schwenger et al. Crit Care 2012; 16: R140

Hybrid treatments

Prospective randomized study  n=332
CVVH vs SLED

Schwenger et al. Crit Care 2012; 16: R140

Table 3 Primary and secondary outcomes.

<table>
<thead>
<tr>
<th></th>
<th>All (n = 332)</th>
<th>SLED (n = 111)</th>
<th>CVVH (n = 117)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death from any cause by day 3</td>
<td>11 (3.3%)</td>
<td>12 (10.8%)</td>
<td>12 (10.3%)</td>
<td>0.47*</td>
</tr>
<tr>
<td>Death from any cause up to 30 August 2009</td>
<td>31 (9.4%)</td>
<td>26 (23.5%)</td>
<td>29 (24.8%)</td>
<td>0.48**</td>
</tr>
<tr>
<td>Weighted mortality</td>
<td>195 (59.2%)</td>
<td>170 (15.4%)</td>
<td>193 (16.3%)</td>
<td>0.48**</td>
</tr>
<tr>
<td>Mortality (ICU)</td>
<td>89 (26.2%)</td>
<td>40 (36.0%)</td>
<td>49 (41.5%)</td>
<td>0.48**</td>
</tr>
<tr>
<td>Mortality (hospital)</td>
<td>101 (30.4%)</td>
<td>57 (51.5%)</td>
<td>106 (89.9%)</td>
<td>0.50**</td>
</tr>
<tr>
<td>Days of mechanical ventilation</td>
<td>1.54 ± 1.7</td>
<td>1.77 ± 1.8</td>
<td>1.54 ± 1.8</td>
<td>0.09</td>
</tr>
<tr>
<td>Days in intensive care unit</td>
<td>21.7 ± 21.1</td>
<td>16.8 ± 20.6</td>
<td>21.7 ± 21.0</td>
<td>0.71</td>
</tr>
<tr>
<td>Recovery of urine frequency days after RRT initiation</td>
<td>156 ± 145</td>
<td>190 ± 142</td>
<td>100 ± 140</td>
<td>0.09</td>
</tr>
<tr>
<td>Persistent renal impairment</td>
<td>126 ± 109</td>
<td>127 ± 104</td>
<td>106 ± 103</td>
<td>0.09</td>
</tr>
<tr>
<td>CPR after hemorrhagic shock</td>
<td>120 ± 64</td>
<td>128 ± 117</td>
<td>104 ± 76</td>
<td>0.09</td>
</tr>
</tbody>
</table>
| PR use per patient per day | 957 ± 152 | 957 ± 157 | 957 ± 150 | 0.64*
| PR use after hemorrhagic shock | 104 ± 207 | 208 ± 113 | 208 ± 200 | 0.09|
| Persistent renal impairment | 15.6 ± 11.3 | 15.4 ± 14.5 | 12.3 ± 11.5 | 0.28*|
Hybrid treatments

**Additional results**
- More decrease of body temp with SLED
- More transfusion in CVVH
- More nursing time in CVVH
- Higher costs with CVVH

**Limitations**
- Single center surgical ICU
- Unblinded
- No objective criteria to stop RRT
- SLED duration increased from planned 12h to 14.9 +/- 4.4
- CVVH duration was 19.9 +/- 3.64

Continuous, intermittent or hybrid?

- This is the wrong question
- Each modality has advantages/disadvantages resulting in specific indications
- The skills and familiarity of the health care workers with the available techniques and the logistic capacity of the ICU may be more important than the choice of the modality

Indications for CRRT or SLED

- Hemodynamic instability
- Important fluid overload
- Risk of intracranial hypertension
**Fluid removal**

Fluid removal more easily achieved with CRRT

![Graph](image)

Bouchard et al. Kidney Intern 2009; 76: 422

**Brain injury**

![Graph](image)


**Brain injury**

Liver failure with cerebral edema

![Graph](image)

Advantages of IHD: costs

Farese et al. Artif Organs 2009; 33: 634-40


Conclusion

Diffusion or convection?
not enough data

Continuous or intermittent or hybrid?
balance advantages - disadvantages
specific indications
local expertise and availability

Peritoneal dialysis in AKI?

PRO                     CON
no vascular access      catheter problems (infection)
no anticoagulation      low efficiency
hemodynamic stability   poorly controllable fluid balance
no expensive equipment  needs intact peritoneal cavity
                       impaired respiratory mechanics
                       protein loss
                       hyperglycemia

Peritoneal dialysis

Prospective RCT  n= 70  severe sepsis
CVVH vs PD

Peritoneal dialysis

Prospective RCT  n= 154     High-volume PD vs daily IHD
Randomisation unclear - 34 patients excluded from final analysis

<table>
<thead>
<tr>
<th></th>
<th>HPD</th>
<th>DHD</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>51±27</td>
<td>75±31</td>
<td>0.02</td>
</tr>
<tr>
<td>Resolution of AKI (days)</td>
<td>72±26</td>
<td>108±47</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Gabriel et al. Kidney Intern Suppl 2008; 73: S87-S93

Peritoneal dialysis

Prospective RCT  n= 407     High-volume PD vs extended daily dialysis
264 patients excluded from final analysis

Ponce et al. Intern Urol Nephrol 2012; in press

Conclusion

Tailored Therapy: Matching the Method to the Patient

Bilene Macedo, Ravindra L. Mehta

... and to the local expertise and availability