Overview

- General Principles of RRT
- Non-renal indications
- Specific concerns w/ RRT

Acute Kidney Injury

- Prevalence in ICU patients 5.7%
- More likely to develop co-morbid conditions
- Mortality w/ RRT remains 50-60%

Indications for Renal Support

- Fluid control
- Electrolyte balance
  - Hyperkalemia
  - Hypokalemia
- Hyperphosphatemia
- Hypermagnesemia
- Acid-base control
  - Metabolic acidosis
  - Mixed acidosis/alkalosis
  - Severe metabolic alkalosis
- Azotemia
- Uremic symptoms
  - Gastrointestinal upset
  - Obtundation
  - Uremic signs
  - Pericarditis
  - Neuropathy
  - Other
  - Toxic removal
Ideal Renal Replacement Therapy

- Controls volume
- Corrects acid-base / metabolic abnormalities
- Improves uremia / toxin clearance
- Promotes renal recovery
- Improves survival
- Hemodynamic stability
- Minimal bleeding / clotting complications

Types of Therapy

<table>
<thead>
<tr>
<th>Hemodialysis</th>
<th>Hemofiltration</th>
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<tr>
<td>- Based on diffusion</td>
<td>- Based on convection via hydrostatic pressure gradient</td>
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<tr>
<td>- Dialysate flows countercurrent to blood</td>
<td>- Plasma water removes solutes as ultrafiltrate</td>
</tr>
<tr>
<td>- Urea, creatinine, K+ diffuse from blood to dialysate</td>
<td>- Replacement fluid given pre- or post-filter</td>
</tr>
<tr>
<td>- Ca2+ &amp; Bicarb from dialysate to blood</td>
<td>- Better for fluid removal</td>
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<tr>
<td>- Effective for clearing small molecules</td>
<td>- Effectively clears medium-sized molecules / less efficient for small molecules</td>
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Modalities of RRT

- Intermittent renal replacement
  - Intermittent hemodialysis (iHD)
  - PUF
- Continuous renal replacement (CRRT)
  - CVVH / CVVHD / CVVHDF
  - SCUF
- Peritoneal dialysis
  - Rarely utilized in ICU setting
- Hybrid therapies
  - SLEDD
  - Extended daily dialysis

Ronco. Critical Care Nephrology. 2008
CRRT

Advantages
- Lower flow rates ➔ greater hemodynamic stability
- Continuous control of volume, pH, electrolytes, uremia
- Theoretical benefit in certain populations
- Unstable hemodynamics
- Less risk of cerebral edema in hepatic failure / TBI
- Removal of sepsis mediators

Disadvantages
- Slow removal of electrolytes/toxins
- Cannot be performed via AV fistula
- Continuous anticoagulation
- Filter clotting (blood loss, gap in therapy)
- Hypothermia
- Electrolyte depletion
- Not available in certain settings

IHD

Advantages
- Less expensive
- Does not require continuous anticoagulation
- Fewer bleeding / clotting complications
- Faster clearance of toxins

Disadvantages
- Osmotic shifts / Dialysis disequilibrium syndrome (CRF)
- Higher rate of intra-dialytic hypotension

CRRT vs. iHD: The Data

CRRT vs. IRRT Meta-analysis (Rabindranath et al. Cochrane Database. 2008)
CRRT vs. iHD: The Data

CONVINT trial (2014):
- Single center, 252 pt, RCT
- No difference in mortality (14, 30d, in-hospital)
- No difference in:
  - Days on RTT
  - Ventilator days
  - Vasopressor use
  - ICU/hosp LOS

Schefold et. al, Crit Care Med. 2014

When to choose iHD vs. CRRT

<table>
<thead>
<tr>
<th>iHD</th>
<th>CRRT</th>
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<tr>
<td>- Severe, life-threatening electrolyte derangements</td>
<td>- Severe hemodynamic instability</td>
</tr>
<tr>
<td>- Rapid clearance of toxins / overdose</td>
<td>- High catabolic states w/ ongoing production of toxins</td>
</tr>
<tr>
<td>- Flash pulmonary edema</td>
<td>- Removal of toxins w/ high intracellular concentrations (e.g. Li+)</td>
</tr>
<tr>
<td>- Liberation from CRRT</td>
<td>- Severe metabolic acidosis w/ inability to compensate</td>
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</tbody>
</table>

Hybrid Therapy: Is SLEDD the answer?

- Essentially IHD at lower blood / dialysate flows for extended period of time (> 5h)
- 11h SLEDD equivalent to 23h CVVH*
- Uses conventional dialysis machine
- Similar hemodynamic stability to CRRT
- Reduced anticoagulation requirement
- Cheaper than CRRT
- Difficulty / complicated drug dosing
  - Risk of underdosing antibiotics during 2nd half of session


Non-renal indications for RRT
### Volume Overload \(\Rightarrow\) SCUF / PUF

- Indicated for volume overload in pre-renal states (e.g. CHF)
- Goal to remove plasma water not solute
- UF not replaced, corresponds to negative fluid balance
- Can be performed w/ either continuous (SCUF) or intermittent (PUF) forms of therapy

### Toxin Clearance:

**What makes a substance dialyzable?**

- Low molecular weight
- Small volume of distribution (primarily blood > peripheral tissues)
- High aqueous solubility
- Low protein binding
- Renal > non-renal contribution to plasma clearance

### Commonly Dialyzable Drugs

- Salicylates
- Theophylline
- Methanol / ethylene glycol / isopropanol
- Barbiturates
- Lithium
- Depakote
- Carbamazepine
- Dabigatran

### Sepsis: a special case for CRRT?

- Clearance of inflammatory cytokines (endotoxin, IL-1, IL-6, IL-10, TNF-α) w/ CVVHDF*
- High-volume hemofiltration (35L UF) appeared favorable in non-controlled trials
- No affect on outcomes regardless of dose in multiple RCTs**
- Further studies w/ high cutoff membranes (greater cytokine removal) & CPFA (coupled plasma filtration and adsorption) are ongoing

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* Peng. Burns. 2005
** Lehner. Minerva Anestesiol. 2014
Specific concerns with the patient on renal replacement therapy

Catheter Site
- Right IJ or femoral sites preferred; Left IJ associated w/ higher rates of catheter failure*
- Better performance & longer filter life w/ catheter tip in right atrium (vs. SVC)**
- Mobilization w/ femoral dialysis catheter safe (controversial)
  - no adverse events; may increase filter life***
- ↑d risk of proximal vein stenosis w/ subclavian location


Nutritional Supplementation
- RRT results in additional protein losses
- Protein supplementation
  - Normal: 1-1.2 g/kg/day
  - Renal Failure (w/o RRT): 0.8-1.2 g/kg/day
  - iHD: 1.2 – 1.4 g/kg/day
  - CVVH: 1.6 – 2 g/kg/day

Summary
- Renal replacement therapy is complicated — work w/ your nephrologist to determine appropriate therapy based on local capabilities
- Data equivocal btw modalities — may be specific situations where one technique is preferred
- CRRT increasingly being used for non-renal applications — understand limitations and pitfalls as well as how to manage them