Pediatric Dialysis Techniques 1: Patient Assessment, Prescription, Dosing, Delivery, Implementation and Monitoring

Theresa Mottes
Scott Sutherland
Jordan Symons

20th International Conference on Advances in Critical Care Nephrology
San Diego 2015
Educational Objectives

Following this session, the participant should be able to:

• Recognize epidemiology of acute kidney injury and the indications for renal replacement therapy (RRT) in critically ill pediatric patients

• Discuss the special technical considerations for pediatric RRT and how they differ from adults

• Understand the unique challenges and potential complications related to RRT for the critically ill child
Renal Replacement for Children

• Critically ill children are at risk for AKI
  – Sepsis, transplantation, congenital heart disease, MODS, etc.

• Renal support helps to maintain metabolic and volume control, bridging the critically ill patient to recovery

• Children may require an approach that differs from critically ill adults
Renal Replacement Therapy

Indications

• Volume overload
• Metabolic imbalance
• Toxins (endogenous or exogenous)
• Inability to provide needed daily fluids due to insufficient urinary excretion

Goals

• Restore fluid, electrolyte and metabolic balance
• Remove endogenous or exogenous toxins as rapidly as possible
• Permit needed therapy and nutrition
• Limit complications
Intermittent Hemodialysis (IHD)

- Blood perfuses extracorporeal circuit
- Dialysate passes on opposite side of membrane
- High efficiency system
- May be poorly tolerated by critically ill patients
- High level of complexity
- No devices specifically for children
Peritoneal Dialysis (PD)

- Sterile dialysate introduced into peritoneal cavity through a catheter
- Lots of pediatric experience
- Low efficiency system
- Possibly better tolerated by critically ill patients?
- Often preferred in infants, especially with congenital heart dz
Continuous Renal Replacement Therapy (CRRT)

- Continuous hemofiltration technique, often used for critically ill patients
- Technically similar to HD
  - SLOW: ICU patients may not tolerate rapid ultrafiltration with HD
  - CONTINUOUS: Preserve metabolic stability; maintain fluid balance for oliguric patients who require high daily input (IV medications, parenteral nutrition)
CRRT Indications: Generalities

• CRRT typically performed in
  – Critically ill children
  – With oliguric AKI
  – That have failed medical management

• CRRT indications in lieu of HD or PD
  – Hemodynamic instability (accurate, predictable UF over extended time)
  – Large volume needs (nutritional support, FFP, high volume meds)
  – Need for convective (vs. diffusive) clearance
CRRT Indications (Really RRT Indications)

- **Fluid Overload**
- Uremia (encephalopathy, bleeding, pericarditis)
- Hyperkalemia
- Metabolic acidosis
- Symptomatic hypocalcemia
- Inadequate nutrition delivered
- Intoxication (including ammonia)
- Terrifyingly high BUN and creatinine (Not necessarily)
- Really bad looking chemistry panels (Probably)
- Hepatic failure/encephalopathy (Maybe)
- Sepsis and other magical indications (Maybe)
## CRRT Indications
ppCRRT Data (n=344)

<table>
<thead>
<tr>
<th>Indication</th>
<th>Patients</th>
<th>% of cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid overload AND electrolyte disturbances</td>
<td>157</td>
<td>46%</td>
</tr>
<tr>
<td>Fluid overload</td>
<td>100</td>
<td>29%</td>
</tr>
<tr>
<td>Electrolyte disturbances</td>
<td>44</td>
<td>13%</td>
</tr>
<tr>
<td>Prevent fluid overload</td>
<td>11</td>
<td>3%</td>
</tr>
<tr>
<td>Other</td>
<td>32</td>
<td>9%</td>
</tr>
</tbody>
</table>

78% of patients received CRRT, at least in part, to treat fluid overload

Basics of Prescribing Pediatric CRRT
Prescribing Pediatric CRRT

• Vascular access
• Prime
• Hemofilter
• Blood pump speed (Q_B)
• Anticoagulation
• Ultrafiltration rate
• Infused fluids (type and flow rates)
Vascular Access for Pediatric CRRT
Vascular Access

• Access function is crucial for therapy
• Low resistance
  – Resistance $\sim 8l\eta/2r^4$
  – Biggest, shortest catheter should be best
• Downtime from clotted circuits, clotted access is time off therapy
• “If you don’t have a good vascular access, you may as well go home”
Circuit Survival Curves by French Size of Catheter

- 376 Patients
- 1574 circuits
- Femoral 69%
- IJ 16%
- Sub-Clavian 8%
- Not Specified 7%

Hackbarth R et al: *IJAIO* December 2007
# Pediatric CRRT – Access Options

<table>
<thead>
<tr>
<th>Patient Size</th>
<th>Catheter Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonates</td>
<td>7 Fr</td>
</tr>
<tr>
<td>3 – 6 Kg</td>
<td>7 Fr</td>
</tr>
<tr>
<td>6 – 12 Kg</td>
<td>8 Fr</td>
</tr>
<tr>
<td>12 – 20 Kg</td>
<td>9 Fr</td>
</tr>
<tr>
<td>20 – 30 Kg</td>
<td>10 Fr</td>
</tr>
<tr>
<td>&gt; 30 Kg</td>
<td>10 – 12 Fr</td>
</tr>
</tbody>
</table>

Adapted from Cincinnati Children’s Hospital Center for Acute Care Nephrology Acute Dialysis/CRRT/Pheresis Access Guideline
Access Considerations

- **Internal Jugular**
  - Very accessible
  - Large caliber (SVC)
  - Great flows
  - Low recirculation rate
  - Risk for Pneumothorax
  - Cardiac monitoring may take precedence

- **Femoral**
  - Usually accessible
  - Smaller than SVC
  - Flow hampered by:
    - Abdominal Pressures
    - Patient movement
  - Risk for retroperitoneal hemorrhage
  - Higher recirculation rate

- **Subclavian**
  - A suboptimal choice
Circuit Priming for Pediatric CRRT
Priming the Circuit for Pediatric CRRT

• Blood
  – Small patient, large extracorporeal volume

• Albumin
  – Hemodynamic instability - ? Risk of hypocalcemia?

• Saline
  – Common default approach

• Self
  – Volume loaded renal failure patient
Blood Prime for Pediatric CRRT

• Smaller patients (e.g. <10-15kg) require blood priming to prevent hypotension/hemodilution
  – Circuit volume > 10-15% patient blood volume

• Example
  – 5 kg infant : Blood Volume = 400 cc (80/kg)
  – Extracorporeal circuit volume = 100 ml
  – Therefore 25% extracorporeal volume

• Technique: prime first with saline, then blood/albumin mix to Hct of ~35
Blood Prime Increases Risks

• Blood product exposure – possibly repeated

• Biochemical imbalances
  – HYPOCALCEMIA
    • Citrate anticoagulant in the PRBCs
  – HYPERKALEMIA
    • K+ release from RBCs – more over time (older unit)
  – ACIDEMIA

• Increases risk for bradykinin release syndrome
Technique Modifications to Prevent Bradykinin Release Syndrome

• Buffered system: add CaCl, NaBicarb to PRBCs
• Bypass system: prime with saline, run PRBCs into patient on venous return line
• Recirculation system: recirculate blood prime against dialysate
• Circuit-to-circuit cross-prime
Bypass System to Prevent Bradykinin Release Syndrome

Recirculation System to Prevent Bradykinin Release Syndrome

Recirculation Plan:
- Qb 200ml/min
- Qd ~40ml/min
- Time 7.5 min

Normalize pH
Normalize K^+

Circuit-to-Circuit Cross-Prime

- Transfer blood from active circuit to new circuit
- No new units of blood from blood bank
- Blood in system already equilibrated to patient
- Need several more hands
- Only good for restarts when current circuit still functioning
Circuit-to-Circuit Cross-Prime
Simple Systems to Limit Likelihood of Bradykinin Release Syndrome

Don’t prime on with blood
Don’t use the AN-69 membrane
Blood Flow Rates for Pediatric CRRT
Choosing $Q_B$ for Pediatric CRRT

- Equation for blood flow rate ($Q_B$):
  - 3-5ml/kg/min – *but where did this come from?*

- Choose from a table:
  - 0-10 kg: 25-50ml/min
  - 11-20kg: 80-100ml/min
  - 21-50kg: 100-150ml/min
  - >50kg: 150-180ml/min – *but why the limitation?*

- CRRT device may affect choices for $Q_B$

The real determinant – *the vascular access*
Infused Fluids (Dialysate and Replacement) for Pediatric CRRT
CRRT Schematic

- SCUF
- CVVH
- CVVHD
- CVVHDF
## CRRT Solutions – Many Choices

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>R / D</th>
<th>Bag Size*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normocarb HF</td>
<td>DSI</td>
<td>R</td>
<td>3.24 L</td>
</tr>
<tr>
<td>Prismasate</td>
<td>Gambro</td>
<td>D</td>
<td>5 L</td>
</tr>
<tr>
<td>Accusol</td>
<td>Baxter</td>
<td>D</td>
<td>2.5 L</td>
</tr>
<tr>
<td>Prismasol</td>
<td>Gambro</td>
<td>R</td>
<td>5 L</td>
</tr>
<tr>
<td>Duosol</td>
<td>B Braun</td>
<td>D</td>
<td>5 L</td>
</tr>
<tr>
<td>PureFlow</td>
<td>NxStage</td>
<td>D</td>
<td>5</td>
</tr>
</tbody>
</table>

*Dialysate mixed on-line for SLED*
Rate for Infused Fluid

• Higher rates increase clearance
• Lower rates may simplify electrolyte balance and limit protein loss
• Equations to help choose rate for fluid:
  – 20-60 ml/kg/hr
  – 2000-3000 ml/hr/1.73m2
• May need higher rates to balance citrate delivery
Does Dose Matter in CRRT?

- Maybe – but that’s hard to prove

The “ATN” Study (NEJM 2008)
  - 1124 adults in the ICU

The “RENAL” Study (NEJM 2009)
  - 1508 adults in the ICU
Anticoagulation for Pediatric CRRT
Anticoagulation

• Another crucial step in delivering the prescribed dose (reducing downtime)
• Critically ill patients are at risk for both increased and decreased clot formation simultaneously
Calcium is necessary for each event in the cascade.

Heparin acts in conjunction with ATIII on thrombin and F IX, FX, FXII.
Anticoagulation

**Systemic Heparin**
- Goal ACT 180-240 sec or aPTT 40-60 sec
- Patient anticoagulated
  - Risk of bleeding
- Risk for HIT

**Regional Citrate**
- Goal Circuit iCal *LOW*
  - 0.3-0.4 mmol/L
- Goal Patient iCal *NORMAL*
  - 1.1-1.4 mmol/L
- Potential complications
  - Hypocalcemia
  - Alkalosis
  - Hypernatremia
Multi-centre evaluation of anticoagulation in patients receiving continuous renal replacement therapy (CRRT)

Patrick D. Brophy¹, Michael J. G. Somers², Michelle A. Baum², Jordan M. Symons³, Nancy McAfee³, James D. Fortenberry⁴, Kristine Rogers⁴, Joni Barnett⁵, Douglas Blowey⁶, Cheryl Baker⁷, Timothy E. Bunchman⁸ and Stuart L. Goldstein⁷

- Mean circuit survival
  - Heparin 42hr
  - Citrate 44hr
  - No ACG 27hr

- Bleeding
  - Heparin: 9 pts
  - Citrate: none

138 Patients/442 Circuits

Heparin 52%
Citrate 36%
No anticoag 12%
Citrate vs. Heparin in Adult CRRT: CASH Study

Patient survival equivalent at 30d

Filter survival better with citrate

Patient survival equivalent at 90d

Lower cost, better safety profile with citrate

Schielder, Critical Care 2014, 18:472
Citrate Specific Issues

• Alkalosis
  – 1 mmol Citrate to 3 mmol HCO3
  – Base content of CRRT fluid (e.g., 35 mEq/L) may exacerbate

• Hypernatremia
  – Tri-sodium citrate infusion

• Citrate excess
  – Incomplete clearance of citrate
    • Liver dysfunction; low clearance rates; high delivery
  – Rising total calcium, decreasing iCal
  – ? More risk for smaller patients?
Anticoagulation for CRRT: Other Options?

• Low molecular weight heparin
• Prostacyclin (epoprostenol)
• Direct thrombin inhibitors
• Other things?
Ultrafiltration for Pediatric CRRT
Ultrafiltration in Pediatric CRRT

• Choose UF rate to
  – balance input
  – remove excess fluid over time
  – “make room” for IV fluids and nutrition
  – provide solute clearance by convection

• SCUF, CVVHD, post-dilution CVVH: UF rate may be limited by blood flow (filtration fraction)

• Pre-dilution CVVH: High flow of pre-dilution fluid lessens hemoconcentration

• Remember to consider UF limits of the filter, especially in higher-volume hemofiltration
Rate Limitations of Volume Removal

Extra-Vascular Compartment  Vascular Compartment

BP
Improved Volume Removal with Slower Ultrafiltration Rates

Extra-Vascular Compartment  Vascular Compartment

BP Stable
Ultrafiltration Rates

• No study has determined effective, safe UF rates in children

• For HEMODIALYSIS—NET UF rate of 0.2ml/kg/min is tolerated (~10-12ml/kg/hr)

Donckerwolke – Ped Neph 8:103-106, 1994
Diffusion, Convection, and Effects of the Membrane
**Diffusion**

- Small molecules diffuse easily
- Larger molecules diffuse slowly
- ? Better to avoid loss of some molecules (e.g., drugs)?
Convection

• Small and large molecules move equally

• Limit is cut-off size of membrane

• ? Advantageous in some settings (e.g., sepsis)?
Clearance: Convection vs. Diffusion
RRT for Critically Ill Patients: Which Modality is Best?

• CRRT vs. IHD
  – Cochrane review (2008): 15 studies of adults with AKI reviewed showing NO DIFFERENCE in outcome

• CRRT modalities
  – Possible benefit with convection in sepsis?
  – Limited data – no controlled study
Hemofilter for CRRT

• Hemofilter size
  – Volume, porosity

• Membrane material
  – Polysulfone, AN-69, PAES, etc.
  – Charge, adsorptive capacity

• Tubing set – integrated or separate?

• “Open” vs. “closed” systems – do you have a choice?
Effect of Pore Size on Membrane Selectivity

- Creatinine: 113 D
- Urea: 60 D
- Glucose: 180 D
- Vancomycin: ~1,500 D
- IL-6: ~25,000 D
- Albumin: ~66,000 D
Effect of Pore Size on Membrane Selectivity

These effects are maximized in *convection*
Other Membrane Characteristics:

e.g., **Charge**

- **Negative charge on membrane:**
  - Negatively charged particles may be repelled, limiting filtration
Other Membrane Characteristics: e.g., **Charge**

- **Negative charge on membrane:**
  - Negatively charged particles may be repelled, limiting filtration
  - Positively charged particles may have increased sieving
Other Membrane Characteristics: e.g., **Charge**

- **Negative charge on membrane:**
  - Negatively charged particles may be repelled, limiting filtration
  - Positively charged particles may have increased sieving
  - Charge may change adsorption
Outcomes for Pediatric CRRT
## Pediatric CRRT Outcomes

### General Survival Rates

<table>
<thead>
<tr>
<th>Study</th>
<th>Age</th>
<th>Pt. #</th>
<th>Survival</th>
<th>Associated with Increased Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunchman et. al. (2001)</td>
<td>6.2y</td>
<td>106</td>
<td>40%</td>
<td>Vasopressor use, non-renal diagnosis</td>
</tr>
<tr>
<td>Goldstein, et. al. (2001)</td>
<td>8.8y</td>
<td>22</td>
<td>43%</td>
<td>Greater FO</td>
</tr>
<tr>
<td>Gillespie (2004)</td>
<td>5.1y</td>
<td>77</td>
<td>50%</td>
<td>Greater FO</td>
</tr>
<tr>
<td>Foland et. al. (2004)</td>
<td>9.6y</td>
<td>113</td>
<td>61%</td>
<td>MODS, Greater FO</td>
</tr>
<tr>
<td>ppCRRT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-Symons et. al. (2007)</td>
<td>8.5y</td>
<td>344</td>
<td>58%</td>
<td>Oncologic disease, MODS, Greater FO,</td>
</tr>
<tr>
<td>-Sutherland et. al. (2010)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hayes, et. al. (2009)</td>
<td>5.8y</td>
<td>76</td>
<td>55%</td>
<td>Sepsis, MODS, Greater FO</td>
</tr>
</tbody>
</table>

Survival rate has improved over time from **40-45%** to **55-60%**

Underlying disease, comorbidities, risk factors determine mortality
## Pediatric CRRT Outcomes
### Survival by Underlying Disease

<table>
<thead>
<tr>
<th>ppCRRT Registry Cohort (n=344)</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Diagnosis</strong></td>
<td></td>
</tr>
<tr>
<td>Liver Disease/Transplant</td>
<td>31%</td>
</tr>
<tr>
<td>Pulmonary Disease/Transplant</td>
<td>45%</td>
</tr>
<tr>
<td>Stem Cell Transplant</td>
<td>45%</td>
</tr>
<tr>
<td>Malignancy (w/o tumor lysis)</td>
<td>48%</td>
</tr>
<tr>
<td>Cardiac Disease/Transplant</td>
<td>51%</td>
</tr>
<tr>
<td>Sepsis</td>
<td>59%</td>
</tr>
<tr>
<td>Ischemia/shock</td>
<td>68%</td>
</tr>
<tr>
<td>Inborn Error of Metabolism</td>
<td>73%</td>
</tr>
<tr>
<td>Renal Disease</td>
<td>84%</td>
</tr>
<tr>
<td>Tumor Lysis Syndrome</td>
<td>83%</td>
</tr>
<tr>
<td>Drug Intoxication</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>71%</td>
</tr>
</tbody>
</table>

# Pediatric CRRT Outcomes

## Risk Factors for Poorer Outcome


<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio (Mortality)</th>
<th>95% Confidence Interval</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid Overload Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥20% FO vs. &lt;10% FO</td>
<td>21.1</td>
<td>5.2 – 85.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>≥20% FO vs. 10%-20% FO</td>
<td>11.2</td>
<td>1.8 – 68.4</td>
<td>0.009</td>
</tr>
<tr>
<td>10%-20% FO vs. &lt;10% FO</td>
<td>1.9</td>
<td>0.33 – 10.8</td>
<td>0.48</td>
</tr>
<tr>
<td>Oncologic Diagnosis</td>
<td>5.8</td>
<td>2.5 – 13.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diagnosis of MODS</td>
<td>3.7</td>
<td>1.4 – 9.9</td>
<td>0.008</td>
</tr>
<tr>
<td>Sepsis Diagnosis</td>
<td>3.6</td>
<td>1.3 – 9.8</td>
<td>0.01</td>
</tr>
<tr>
<td>Convective CRRT Modality</td>
<td>0.49</td>
<td>0.28 – 0.86</td>
<td>0.01</td>
</tr>
<tr>
<td>PRISM II PICU Admission</td>
<td>1.04</td>
<td>1.0 – 1.1</td>
<td>0.07</td>
</tr>
<tr>
<td>IEM/Intoxication Diagnosis</td>
<td>3.4</td>
<td>0.75 – 15.2</td>
<td>0.11</td>
</tr>
<tr>
<td>Inotrope Number</td>
<td>1.2</td>
<td>0.9 – 1.6</td>
<td>0.17</td>
</tr>
<tr>
<td>CRRT Initiated to treat FO</td>
<td>1.5</td>
<td>0.66 – 3.4</td>
<td>0.34</td>
</tr>
<tr>
<td>Age at CRRT Initiation</td>
<td>1.01</td>
<td>0.97 – 1.05</td>
<td>0.63</td>
</tr>
<tr>
<td>Sex</td>
<td>0.96</td>
<td>0.55 – 1.7</td>
<td>0.88</td>
</tr>
</tbody>
</table>
Pediatric CRRT Outcomes

Risk Factors: Fluid Overload


<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio (Mortality)</th>
<th>95% Confidence Interval</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid Overload Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥20% FO vs. &lt;10% FO</td>
<td>21.1</td>
<td>1.8 – 68.4</td>
<td>0.009</td>
</tr>
<tr>
<td>≥20% FO vs. 10%-20% FO</td>
<td>11.2</td>
<td>0.33 – 10.8</td>
<td>0.48</td>
</tr>
<tr>
<td>10%-20% FO vs. &lt;10% FO</td>
<td>1.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oncologic Diagnosis</td>
<td>5.8</td>
<td>2.5 – 13.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diagnosis of MODS</td>
<td>3.7</td>
<td>1.4 – 9.9</td>
<td>0.008</td>
</tr>
<tr>
<td>Sepsis Diagnosis</td>
<td>3.6</td>
<td>1.3 – 9.8</td>
<td>0.01</td>
</tr>
<tr>
<td>Convective CRRT Modality</td>
<td>0.49</td>
<td>0.28 – 0.86</td>
<td>0.01</td>
</tr>
<tr>
<td>PRISM II PICU Admission</td>
<td>1.04</td>
<td>1.0 – 1.1</td>
<td>0.07</td>
</tr>
<tr>
<td>IEM/Intoxication Diagnosis</td>
<td>3.4</td>
<td>0.75 – 15.2</td>
<td>0.11</td>
</tr>
<tr>
<td>Inotrope Number</td>
<td>1.2</td>
<td>0.9 – 1.6</td>
<td>0.17</td>
</tr>
<tr>
<td>CRRT Initiated to treat FO</td>
<td>1.5</td>
<td>0.66 – 3.4</td>
<td>0.34</td>
</tr>
<tr>
<td>Age at CRRT Initiation</td>
<td>1.01</td>
<td>0.97 – 1.05</td>
<td>0.63</td>
</tr>
<tr>
<td>Sex</td>
<td>0.96</td>
<td>0.55 – 1.7</td>
<td>0.88</td>
</tr>
</tbody>
</table>

If treated as a continuous variable, odds ratio for FO is 1.03

For every 1% increase in FO, mortality increases by 3%, even after adjusting for severity of illness.
Pediatric CRRT Outcomes
Risk Factors: The Illest of the ill

• Retrospective, single center analysis of ECMO data base
  – 154/378 patients received ECMO and CRRT
  – 68/154 (44%) survived to hospital discharge
  – 65/68 (96%) RECOVERED RENAL FUNCTION AND DID NOT REQUIRE RRT AT DISCHARGE

• 3/68 who required RRT at discharge all had primary renal disease

Pediatric CRRT Outcomes
Long term outcomes AKI (1)

• Original study of 245 inpatients with AKI
• 174 kids survived to hospital discharge and had long term data available
  – Survival amongst these kids was ~ 80% (139/174)
  – Of these deaths, ~ 70% occurred in the first 12mo
• At 3-5 years post hospital discharge
  – Renal survival ~ 90%
  – WORSE in those with primary renal disease (69% vs. 96%)
  – 60% of patients (n=29) had either microalbuminuria, hyperfiltration, reduced GFR, or hypertension

Pediatric CRRT Outcomes
Long term outcomes AKI (2)

- 126 pts who experienced AKI in the ICU, survived, and received follow up.
  - 35% AKIN stage I
  - 37% AKIN stage 2
  - 28% AKIN stage 3

- After 1-3y 10.3% had CKD (GFR<60, albuminuria)
  - Trend towards greater CKD prevalence with increasing AKIN stage (4.5% -> 10.6% -> 17.1%)

- An additional 47% of patients had a GFR 60-90, hypertension, and/or hyperfiltration

Pediatric CRRT Outcomes

• Overall survival ranges from 45-60%
  – Hinges on underlying disease
  – Poorer survival with MODS, Oncologic illness, and greater fluid overload

• Survivors can expect recovery of renal function
  – Unless cause of AKI is a primary renal disease

• Survivors are likely to have long-term sequelae and require long term follow up
  – Hypertension, proteinuria, chronic kidney disease
RRT in Critically Ill Children: Summary

• All modalities are available and should be considered depending on the clinical scenario
• CRRT may offer benefits but we lack proof
• CRRT for children requires special considerations given size, equipment
• Acute outcome depends heavily on diagnosis; long-term outcome may include CKD
• Thoughtful planning and teamwork will help us do the best for our young patients