CRRT in ECMO Patients: Techniques and Outcomes from the ELSO Registry

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17th Annual CRRT Meeting
Objectives

- Discuss how RRT is performed in critically ill patients on ECMO
- Review the incidence and outcomes in ECMO patients with AKI / RRT.
- Assess if AKI and RRT provision are independently associated with mortality
Extracorporeal Membrane Oxygenation (ECMO)

- Indications for ECMO
  - Severe acute heart or lung failure
  - Expected mortality risk ≥ 80% despite optimal conventional therapy
- ECMO initiation usually improves hemodynamic status

ELSO Registry General Guidelines. April 2009
ECMO initiation may predispose patients to AKI

- ECMO initiation causes
  - Increased inflammatory response \(^1\)
  - Hypercoaguable state \(^2\)
  - Hemolysis/ Hemoglobinuria \(^3\)

1. Kurundkar et al. *Pediatric Research* August 2010
2. Shapiro A. *Seminars in Hematology* 1995
3. Toomasian J. and Bartlett R. *Perfusion* 2011
Not surprising that these patients develop AKI
Technical Considerations
How do you do it? Access
ECMO and RRT System

Adapted from Hoover N et al. Intensive Care Medicine, 2008.
CRRT machines with ECMO

- Access Pressure on CRRT may be positive
  - Some Dialysis Machines can allow for alarms to be adjusted during ECMO
  - Clamps can be used to avoid these alarms
    - Increases Hemolysis

- Circuit prime
  - Can use either a saline prime or blood prime
  - Careful with heparin rinse
ECMO and In-Line Hemofilter System

Adapted from Hoover N et al. Intensive Care Medicine, 2008.
ECMO and In-Line Hemofilter System

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ECMO and In-Line Hemofilter System

Adapted from Hoover N et al. Intensive Care Medicine, 2008.
CRRT on ECMO using “Homemade” In-Line system

- Must return “dialyzed blood” pre BLADDER
- IV infusion pumps control ultrafiltrate
  - Up to 12.5 % inaccuracies in some studies
  - IV pumps are not engineered to maintain accuracy at higher pressures
Ultrafiltration Error Rate Increases with Increasing Flow/Pressure Differential

Sucosky, Paden et al., JMD 2008
What type of modality is used

- NO RRT
- IN-LINE
- RRT Machine
- unknown

Modality with RRT machine

- SCUF
- CVVH
- CVVHD
- CVVHDF

KIDMO Study Group
Modality w/ In-Line Hemofilter

KIDMO Study Group
## Differences between RRT methods

<table>
<thead>
<tr>
<th></th>
<th>In Line Hemofilter</th>
<th>CRRTT machine</th>
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</thead>
<tbody>
<tr>
<td><strong>Ultrafiltration control</strong></td>
<td>IV pump controlled</td>
<td>CRRTT machine controlled</td>
</tr>
<tr>
<td><strong>Metabolic Control</strong></td>
<td>NOT if only using SCUF</td>
<td>YES</td>
</tr>
<tr>
<td><strong>ECMO Flow</strong></td>
<td>Blood Shunt</td>
<td>NO systemic changes</td>
</tr>
<tr>
<td></td>
<td>decrease ECMO flow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>decreased PaO2</td>
<td></td>
</tr>
<tr>
<td><strong>Complexity</strong></td>
<td>Less People</td>
<td>More People</td>
</tr>
</tbody>
</table>
Epidemiology of AKI in ECMO patients
How often does AKI happen in ECMO patients?

- Single Center Pediatric Data
  - Neonates with congenital diaphragmatic hernia (CDH) $^1$ – 84%
  - Children with Cardiac Indications $^2$ – 71%

1. Gadepalli et al. Pediatric Surgery July 2010
2. Smith et al. ASAIO 2009
Retrospective analysis of 46 adults on ECMO using RIFLE

- F (24%)
- NO (22%)
- R (15%)
- I (39%)

78% of patients had AKI

Lin, C.-Y. et al. NDT. 2006
RIFLE in adults on ECMO

Lin, C.-Y. et al. NDT. 2006

Survival

- Non-ARF: 8/10 (80%)
- RIFLE-I: 3/7 (57%)
- RIFLE-R: 5/18 (28%)
- RIFLE-F: 0/11 (0%)
81% incidence of AKI

Yan X. et al.; Eur J Cardthorac Surg 2010
Adults on ECMO Post-Cardiotomy

**AKI by RIFLE at 48 hours**
Stage F vs. NO AKI
Independent OR for death
= **12.6** (95% CI = 2.2–72.3)  
\[ p = 0.005 \]

**AKI by AKIN at 48 hours**
Stage 3 vs NO AKI
Independent OR for Death
= **30.8** (95% CI = 3.3–287.2)  
\[ p = 0.003 \]

Yan X. et al.; Eur J Cardthorac Surg 2010
RRT provision is associated with poor survival

Paden et al. PCCM March 2011
RRT provision is associated with poor survival

Paden et al. PCCM March 2011
ELSO Registry 1985-2008: Pediatric Cardiac Indications

No dialysis | Dialysis
---|---
0-30 days | 0-30 days
1-12 months | 1-12 months
1-16 years | 1-16 years
> 16 years | > 16 years
Are AKI / RRT independently associated with mortality in ECMO patients?

Association ≠ Causality
Extracorporeal Life Support Organization (ELSO) Registry

- ELSO Registry
  - Composed of nearly all ECMO cases worldwide
  - Over 40,000 cases
  - 2 separate registries – cardiac and noncardiac
ELSO Registry – 1998 - 2008

Neonates

N = 7941 children
ELSO Registry – 1998 - 2008

N = 1962 children
ELSO Registry – 1998 - 2008

Adults

N = 1011 adults
Variables Analyzed

- Outcome – Survival vs. Non-survival
- Primary exposures of interest
  - AKI
    - Complication code of SCr ≥ 1.5 mg/dl or
    - ICD-9 code of Acute renal failure
  - Dialysis
    - CPT codes used
Potential Confounders Analyzed

- Demographics
- Physiologic Data before ECMO
- Physiologic Data during ECMO
- Therapy characteristics
- Co-morbid conditions
- Complications
- Interventions

Askenazi et al. Pediatric CCM 2011
ELSO Registry - Neonates

Askenazi et al. Pediatric CCM 2011
Pediatric ELSO registry

Askenazi et al. Pediatric Critical Care Medicine 2011
Adult Non-Cardiac ELSO Registry

- AKI: 7%
- Both: 27%
- RRT: 15%
- Neither: 51%
Survival in AKI/ RRT subjects

Askenazi et al. Pediatric Critical Care Medicine 2011
Survival in AKI/ RRT subjects

Askenazi et al. Pediatric Critical Care Medicine 2011
<table>
<thead>
<tr>
<th></th>
<th>Crude OR</th>
<th>Adjusted OR</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonate AKI</td>
<td>5.8</td>
<td>3.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RRT</td>
<td>3.5</td>
<td>1.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Children AKI</td>
<td>3.5</td>
<td>1.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RRT</td>
<td>3.2</td>
<td>2.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Adult AKI</td>
<td>2.8</td>
<td>1.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>RRT</td>
<td>2.6</td>
<td>3.0</td>
<td>&lt;0.001</td>
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Askenazi et al. Pediatric Critical Care Medicine 2011
AKI / RRT are Independently Associated with Adult Mortality

Propensity Score Matched Case-Control

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<thead>
<tr>
<th></th>
<th>Crude</th>
<th>Propensity score matched</th>
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</thead>
<tbody>
<tr>
<td><strong>Acute Kidney Injury</strong></td>
<td>2.78 (2.14–3.60)</td>
<td>1.32 (1.12–1.55)</td>
</tr>
<tr>
<td><strong>Odds Ratio (95% CI)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>p-value</strong></td>
<td></td>
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<tr>
<td><strong>Renal Replacement Therapy</strong></td>
<td>2.57 (2.00–3.31)</td>
<td>2.09 (1.82–2.40)</td>
</tr>
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<td><strong>Odds Ratio (95% CI)</strong></td>
<td></td>
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Summary

- ECMO patients can receive RRT on ECMO
  - CRRT machine – in series
  - In-line hemofilter
    - Watch Ultrafiltration carefully!
Summary

- ECMO patients can receive RRT on ECMO
- Acute Kidney Injury is extremely common in ECMO patients
- Those with AKI and those who receive RRT have worse outcomes – independent of important confounders
- Improved understanding of how best to support ECMO patients with AKI is likely to improve outcomes