Fluid Overload Predicts Morbidity and Mortality in Neonates Following Cardiac Surgery

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Introduction

Acute kidney injury (AKI) is a severe complication of cardiac surgery associated with increased morbidity and mortality. All current AKI classification systems (RIFLE, pediatric RIFLE, and AKIN) rely on measured serum creatinine (sCr) levels and/or oliguria to diagnose AKI.

Several difficulties exist in diagnosing AKI in neonates:
1. sCr may reflect maternal renal function.
2. Neonates experience rapid changes in glomerular filtration rate dependent on level of prematurity and post-natal age.
3. >50% of documented neonatal AKI cases are non-oliguric.

Given these difficulties, an alternative to sCr based classification systems was pursued.

Purpose

To examine whether degree of fluid overload (FO), a readily-available, non-invasive marker of renal function, could be a predictor of poor outcomes in neonates undergoing cardiac surgery requiring cardiopulmonary bypass (CPB).

Results

- 503 neonates without history of previous sternotomy or ECMO underwent cardiac surgery with CPB during the 5-year period.
- 74 of these (14.7%) died, required RRT, or were placed on ECMO within 72 post-operative hours, and were excluded from further analysis.
- Within the remaining 429 neonates, 15 (3.5%) had a poor outcome (Table 1).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>All</th>
<th>Poor outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex</td>
<td>260 (60.6)</td>
<td>8 (53.3)</td>
</tr>
<tr>
<td>Age at surgery, days</td>
<td>7 (5-10)</td>
<td>6 (3-10)</td>
</tr>
<tr>
<td>Type of Ventricle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>170 (38.6)</td>
<td>10 (66.7)</td>
</tr>
<tr>
<td>Two</td>
<td>259 (60.4)</td>
<td>5 (33.3)</td>
</tr>
<tr>
<td>RACHS-1 classification¹</td>
<td></td>
<td></td>
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<tr>
<td>1 - 4</td>
<td>307 (71.6)</td>
<td>8 (53.3)</td>
</tr>
<tr>
<td>5 or 6</td>
<td>122 (28.4)</td>
<td>7 (46.7)</td>
</tr>
<tr>
<td>Gestational age, weeks</td>
<td>39 (38-40)</td>
<td>39 (38-40)</td>
</tr>
<tr>
<td>Prematurity (&lt; 37 weeks)</td>
<td>45 (10.5)</td>
<td>1 (6.7)</td>
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</tbody>
</table>

Pre-Operative

- Baseline Weight, kg 3.00 ± 0.59
- Baseline sCr, mg/dL 0.5 (0.3-0.6)

Intra-Operative

- Cross-clamp time, min 39 (28-58)
- CPB, min 93 (69-128)
- DHCA 237 (95.2)

Post-Operative

- FO on POD 3, % 10.0 (3.2-18.3) 16.7 (5.0-30.6) 8.9 (3.0-17.9) 0.04 | 1.03 | 1.01 (0.6)
- sCr on POD 3, mg/dL 0.6 (0.5-0.9) 0.9 (0.6-1.3) 0.6 (0.5-0.8) 0.01 | 1.35 | 1.27 (3.3)
- Peak sCr, mg/dL 0.8 (0.6-1.0) 1.0 (0.8-1.3) 0.8 (0.6-1.0) 0.01 | 3.62 | 1.16 (11.08)

Conclusions

- A majority of neonates met current AKI criteria:
  - 70.6% RIFLE Risk (Sr ≥ 1.5 times baseline)
  - 77.9% pRIFLE Risk (25% decrease in eGFR from baseline)
  - 65.5% AKIN Stage I (absolute rise in sCr ≥ 0.3 from baseline)

- Using a receiver operating characteristic (ROC) curve, an optimal FO cut-off of 16% was observed with an area under the curve (AUC) of 0.66 for poor outcome (sensitivity=0.60, specificity=0.70) with a positive predictive value of 0.07 and a negative predictive value of 0.98.

- Unadjusted odds ratio (OR) of poor outcome using the optimal cut-off value FO >16% was 3.48 with 95% confidence interval of 1.20-10.73.

- Multivariate logistic regression demonstrates that FO >16 and sCr level on POD 3 are independent predictors of having a poor outcome (Table 2).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>AOR</th>
<th>95% CI of AOR</th>
<th>P-value</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FO based on weight on POD 3 ≥ 16%</td>
<td>4.23</td>
<td>1.35, 13.30</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>sCr on POD 3, mg/dL</td>
<td>5.12</td>
<td>1.61, 16.30</td>
<td>0.006</td>
<td></td>
</tr>
<tr>
<td>Single Ventricle</td>
<td>2.50</td>
<td>0.74, 8.46</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Deep hypothermic circulatory arrest</td>
<td>3.04</td>
<td>0.74, 12.49</td>
<td>0.12</td>
<td></td>
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</tbody>
</table>

References


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¶ E Donohue, MPH

Method

- Design: Retrospective cohort study
- Sample: ≤ 30 days old undergoing cardiac surgery with CPB at the University of Michigan between Jan 2006 - Dec 2010
- Exclusion criteria:
  - Previous sternotomy
  - Previous extracorporeal membrane oxygenation (ECMO)
  - Death, renal replacement therapy (RRT), or ECMO within 72 post-operative hours
- Data collected:
  - Demographic, anatomic, surgical, CPB, and postoperative data
  - Daily weights and sCr levels for postoperative day (POD) 0-3
- A composite poor outcome was used, including:
  1) RRT
  2) Death
  3) ECMO on POD 4-30
- A multivariate logistic regression model was constructed

Table 1. Demographic and Clinical Characteristics in Neonates following Cardiac Surgery

Table 2. Adjusted Odds Ratio of Poor Outcome in Neonatal Cardiac Surgery