Salt and Water Balance in the Critically ill Patient

Chhavi Katyal M.D.
Assistant Professor of Pediatrics
Division of Pediatric Critical Care Medicine
Albert Einstein College of Medicine
Fluid and Electrolyte Balance in Critical Illness

- Acute Lung Injury (ALI) and fluid balance
  - FACTT trial
  - Pediatric trials
- Relationship of fluid overload to acute kidney injury and mortality
- Dosing of salt in critical illness
Comparison of Two Fluid-Management Strategies in Acute Lung Injury

Conservative
• Fluid and Diuretic therapies to achieve
• Goal CVP <4mmHg or PAOP <8mmHg
• Maintain a MAP>60mmHg
• effective circulation
• Urine output 0.5ml/kg/hr

Liberal
• Fluid and Diuretic therapies to achieve a
• Goal CVP <10-14mmHg or PAOP <14mmHg
• Maintain a MAP>60mmHg
• effective circulation
• Urine output 0.5ml/kg/hr

N Engl J Med 2006;354:2564-75
Comparison of Two Fluid-Management Strategies in Acute Lung Injury

<table>
<thead>
<tr>
<th></th>
<th>Conservative</th>
<th>Liberal</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Cumulative Fluid Balance (first 7 days)</td>
<td>-136±491</td>
<td>6992±502</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Patients in shock at baseline</td>
<td>2904±1008</td>
<td>10138±922</td>
<td>&lt;0.001</td>
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<tr>
<td>Patients not in shock at baseline</td>
<td>-1576±519</td>
<td>5278±576</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Ventilator Free Days</td>
<td>14.6±0.5</td>
<td>12.1±0.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Days not spent in the intensive care unit (During the first 28 days)</td>
<td>13.4±0.4</td>
<td>11.2±0.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Use of Dialysis (During first 60 days)</td>
<td>10%</td>
<td>14%</td>
<td>0.06</td>
</tr>
</tbody>
</table>

N Engl J Med 2006;354:2564-75
Fluid Balance in critically ill children with acute lung injury

- Retrospective review of 168 patients
- 5 ICU’s
- Age 1-18
- Weight adjusted fluid balance (ml/kg)
- Compare the data with FACTT trial
Fluid balance in Critically Ill Children with Acute Lung Injury

Figure 2. Comparison of cumulative fluid balance (mL/kg/day) in the Fluid and Catheter Therapy Trial (FACTT) to the pediatric intensive care unit (ICU) cohort. Cumulative fluid balance (mL/kg/day) in the pediatric ICU was significantly greater than that of the FACTT conservative group on study days 1-7, *p < .02. Error bars represent standard error (SE).
Fluid overload in Children

- Fluid overload, impaired oxygenation, and morbidity in critically ill children
  - Retrospective Review
  - 80 patients
  - Higher fluid overload predicted higher oxygenation index ($p<0.009$)
  - Longer duration of ventilation ($p=0.004$)
  - Longer Hospital Stay ($p=0.02$)

Fluid balance in Critically Ill children with Acute Lung Injury

• Positive fluid balance at Day 3 associated with fewer days alive and free of mechanical ventilator support.
• Greater fluid load at the initiation of continuous renal replacement therapy associated with higher mortality
Relationship of fluid overload to acute kidney injury and mortality
Fluid balance, Diuretic Use, and Mortality in Acute Kidney Injury

- Data from the FACTT trial
- Evaluation of Post Renal Injury fluid balance and diuretic use
- 306 Patients developed AKI within 2 days of enrollment.
  - Positive fluid balance after diagnosis of AKI was associated with increased mortality
  - Risk of death 1.6 fold higher per L/day of fluid accumulated.
  - Diuretic therapy was associated with survival.

Fluid overload, acute kidney injury, and mortality

- Sepsis Occurrence in Acutely Ill Patients study (SOAP; n = 3,147),
  - 36 % of patients had acute renal failure (30.2 % mortality)
  - 12.1 % mortality in the non-acute renal failure group (p < 0.01)
  - renal replacement therapy (RRT),
    - late initiation (>2 days after ICU admission)
    - higher ICU mortality (late 61.5 % vs. early 39.4 %; p < 0.01)

Crit Care 12:R74
Fluid overload, acute kidney injury, and mortality

• Program to Improve Care in Acute Renal Disease (PICKARD) study
  – 618 critically ill patients with AKI were examined.
  – The mean percentage fluid accumulation
    – survivors 8.8 %
    – non-survivors 14.2 %; p < 0.001.

• The odds ratio for death for patients with fluid overload compared to those without fluid overload 2.07 (95% CI 1.3–3.4)

Kidney Int 76:422–427
Fluid overload, acute kidney injury, and mortality

- Fluid overload in infants following congenital heart surgery
  - Prospective, observational study
  - Forty-nine infants < 6 months of age undergoing congenital heart surgery with cardiopulmonary bypass
  - Forty-two patients (86%) met AKI stage 1 criteria (serum creatinine rise of 50% or ≥ 0.3mg/dL).
  - Poor outcomes associated with higher mean maximum fluid overload (12% ± 10% vs. 6% ± 4%, p = 0.03)
    - Poor outcomes--need for CRRT, upper quartile values for ventilator times (>6.5 days) and intensive care length of stay (>9.9 days)

Renal Replacement Therapy and Fluid overload
Fluid overload before CVVH and survival

- Fluid overload before continuous hemofiltration and survival in critically ill children: a retrospective analysis
- Percent fluid overload = (Total fluid input – output) / weight
- Retrospective Review of 113 patients
- 61% survival
- Fluid overload was lower in survivors (7.8%) vs non-survivors (15%)

Dosing of salt in critical illness
Hypotonic vs Isotonic Fluids

- Surgical patients 6 months to 16 years
- Expected postoperative stay of over 24hrs
- 258 patients enrolled
- Randomly assigned to Isotonic (0.9% saline) or Hypotonic (.45% saline) maintenance solution for 48 hrs.

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Hypotonic vs Isotonic Fluids

• Primary Outcome: Plasma sodium level <134 mmol/L

• Secondary Outcomes:
  – Severe hyponatremia (<129 mmol/L)
  – Hypernatremia (>146 mmol/L)
  – Plasma ADH Levels

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Hypotonic vs Isotonic Fluids

• Hypotonic Fluids significantly increased the risk of hyponatremia 40% vs 22% (p=0.004)
• Isotonic Fluids did not increase the risk of hypernatremia.
• No difference in ADH levels between the two groups.
  – Peaked at 24 hrs and normalized the next day.

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Conclusion