Nutrition for Pediatric ECMO

David S. Cooper MD, MPH
Chief Safety Officer - The Heart Institute
Associate Medical Director, Cardiac Intensive Care Unit
Medical Director, Cardiac Extracorporeal Life Support Program
Cincinnati Children’s Hospital Medical Center
Associate Professor of Pediatrics
University of Cincinnati
I have no financial conflicts of interest....
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Background
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- Timely and adequate nutrition is essential to improve outcomes in critically ill children
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• Critically ill children (esp. neonates) have limited endogenous nutrient stores and relatively high nutritional requirements
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- Critically ill children (esp. neonates) have limited endogenous nutrient stores and relatively high nutritional requirements
  - Early institution of nutritional support is important
- In critically ill adults early nutritional support is known to reduce sepsis-associated morbidity and cost
- Patients on ECMO are believed to be more “fragile” and at higher risk for GI complications
- Marked practice variation among centers
Metabolic Response to Critical Illness

• Metabolic state is very heterogeneous in the critically ill child
• Systemic inflammatory response syndrome has been shown to affect metabolism
• Can lead to a state of “Metabolic Dysregulation”
Metabolic Dysregulation
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- Abnormal fuel utilization to provide energy for the critically ill child
Metabolic Dysregulation

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- Characterized by:
  - Increased serum counter-regulatory hormones
  - Increased cortisol and catecholamines
  - Negative protein balance
  - Altered lipid metabolism and release of cytokines
Significant Nutritional and Metabolic Burden
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- Not a period of “metabolic rest”
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- Extremely high protein catabolism while on ECMO (esp. neonates)
  - Neonates can lose up to 15% of their lean body mass during a 7 day run on ECMO
  - Neonates on ECMO have been shown to achieve positive Nitrogen balance when on > 60 kcal/kg

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- No growth expected in the short term

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• If Indirect Calorimetry is not available or feasible, REE prediction is recommended (WHO tables)
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- Indirect Calorimetry (IC) is the preferred method to establish resting energy needs
- Predictive Equations are not reliable
- If Indirect Calorimetry is not available or feasible, REE prediction is recommended (WHO tables)
- Energy expenditure should be re-assessed often throughout the course of illness
anyone can be cool, but awesome takes practice.
Route of Nutrition
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    - Intestinal ischemia $\rightarrow$ necrotizing enterocolitis (NEC)
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  - Hemodynamic alterations (absence of pulsatibility) present in patients on ECMO also have a negative effect on gut barrier function
Gut Hormone Profiles in Critically Ill Neonates on Extracorporeal Membrane Oxygenation

*M. N. Hanekamp, *M. Spoel, *M. Sharman-Koendjbiharie, †W. C. Hop, ‡W. P. Hopman,
‡J. B. Jansen, and *D. Tibboel
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• 24 consecutive infants on VA ECMO
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• 12 TPN only and 12 were given enteral nutrition later and compared to non-ECMO age matched controls
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• Concentrations of gastrin, cholecystokinin and peptide-YY were significantly higher in ECMO patients receiving enteral nutrition compared with TPN.
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12 TPN only and 12 were given enteral nutrition later and compared to non-ECMO age matched controls

Concentrations of gastrin, cholecystokinin and peptide-YY were significantly higher in ECMO patients receiving enteral nutrition compared with TPN.

Overall, plasma hormone levels did not differ from those in age-matched controls.
Routine enteral nutrition in neonates on extracorporeal membrane oxygenation*

Manon N. Hanekamp, MD; Marjolein Spoel, MD; Irene Sharman-Koendjibiharie, MD; Jeroen W. B. Peters; PhD; Marcel J. J. Albers, MD; Dick Tibboel, PhD
• Retrospective review of 67 neonates treated with VA-ECMO from 1997-2002. Patients with CDH were excluded.
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• Feasibility of feeding was evaluated by recording the time period needed for enteral nutrition to reach 40% of total fluid intake. Tolerance was evaluated by reviewing data on enteral nutrition related morbidity.
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Feasibility of feeding was evaluated by recording the time period needed for enteral nutrition to reach 40% of total fluid intake. Tolerance was evaluated by reviewing data on enteral nutrition related morbidity.

36 patients (54%) received 40% of total fluid intake as enteral nutrition within a median of 3 (range, 2–4) days. Over time there was a trend toward an increasing usage of enteral nutrition from 71% to 94% (p= 0.07).
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*This research was supported by grants from the Dutch Heart Foundation.
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Table 2. Enteral feeding related morbidity

<table>
<thead>
<tr>
<th>Condition</th>
<th>No.</th>
<th>Median Time Period to Stop Enteral Nutrition in Hrs (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastric retentions (median 9 mL, range 4-31 mL)</td>
<td>14</td>
<td>24 (8-60)</td>
</tr>
<tr>
<td>Discomfort</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Aspiration</td>
<td>1</td>
<td>Not resumed during ECMO</td>
</tr>
<tr>
<td>Positive blood cultures with enteric bacterium</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Total Enteral Nutrition versus Total Parenteral Nutrition During Pediatric ECMO
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- Both groups were similar in age, weight, pre-ECMO oxygenation index, alveolar-arterial oxygen difference, type, and duration of ECMO. No difference in percent ideal body weight on admission.
- There was no difference between the two groups in the time needed to achieve caloric goal from the initiation of ECMO.

Total Enteral Nutrition versus Total Parenteral Nutrition During Pediatric ECMO

<table>
<thead>
<tr>
<th>Vasoactive Drug</th>
<th>Patients in Group A</th>
<th>Range of Dose (µg/kg/min)</th>
<th>Patients in Group B</th>
<th>Range of Dose (µg/kg/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dopamine</td>
<td>9</td>
<td>2–15</td>
<td>9</td>
<td>3–20</td>
</tr>
<tr>
<td>Nitroprusside</td>
<td>7</td>
<td>1.5–8</td>
<td>8</td>
<td>0.5–6.5</td>
</tr>
<tr>
<td>Milrinone</td>
<td>1</td>
<td>1</td>
<td>7</td>
<td>0.5–0.7</td>
</tr>
<tr>
<td>Enalapril</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>Labetolol</td>
<td>0</td>
<td>30–60^</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Dobutamine</td>
<td>8</td>
<td>5–10</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Norepinephrine</td>
<td>1</td>
<td>0.4</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>3</td>
<td>0.1–0.2</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>0</td>
<td></td>
<td>1</td>
<td>20–60</td>
</tr>
<tr>
<td>Esmolol</td>
<td>0</td>
<td></td>
<td>1</td>
<td>250</td>
</tr>
</tbody>
</table>

^Dose in mg/hr.
## Total Enteral Nutrition versus Total Parenteral Nutrition During Pediatric ECMO

### Table: Reason to Interrupt Feedings During Pediatric ECMO

<table>
<thead>
<tr>
<th>Reason To Interrupt Feedings</th>
<th>No. of Occurrences</th>
<th>Hours Interrupted (Range)</th>
<th>Median (hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decannulation</td>
<td>6</td>
<td>5–56</td>
<td>8.5</td>
</tr>
<tr>
<td>Bronchoscopy</td>
<td>5</td>
<td>2–9</td>
<td>7</td>
</tr>
<tr>
<td>Cannulation</td>
<td>4</td>
<td>5–23</td>
<td>8.5</td>
</tr>
<tr>
<td>Distention</td>
<td>2</td>
<td>13–26</td>
<td>19.5</td>
</tr>
<tr>
<td>Increased residual</td>
<td>1</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Cardiac arrest</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Tube occluded</td>
<td>1</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20</td>
<td>2–56</td>
<td>8</td>
</tr>
</tbody>
</table>

*Feedings not restarted due to inability to replace tube secondary to excessive nasal and oral bleeding.*
No complications were associated with the utilization of enteral feedings.
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- No complications were associated with the utilization of enteral feedings.
- Savings for the nutritional supplement was estimated to be $170 per day for the enterally fed group.
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• Savings for the nutritional supplement was estimated to be $170 per day for the enterally fed group.

• The percentage of patients surviving was higher in the enterally fed patients compared with the parenterally fed group (79% vs. 100%), although this difference was not statistically significant (p = .47).
A.S.P.E.N. Clinical Guidelines: Nutrition Support of Neonates Supported with Extracorporeal Membrane Oxygenation

Tom Jaksic, MD, PhD; Melissa A. Hull, MD; Biren P. Modi, MD; Y. Avery Ching, MD; Donald George, MD; Charlene Compher, PhD, RD, FADA, CNSC; and the American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) Board of Directors

Table 5. Energy Requirements in Neonates Supported with Extracorporeal Membrane Oxygenation (ECMO)

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Study Groups</th>
<th>Results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ECMO (N=10), Postoperative non-ECMO neonates (N=8)</td>
<td>CO₂ breath samples after NaH¹³CO₃ infusion</td>
<td>REE: control 53±5.1 kcal/kg/d, ECMO 55±20 kcal/kg/d Mortality: controls 0%, ECMO 30% IL-6: controls 0.7±0.6 pg/mL, ECMO 29±11.5 pg/mL, P&lt;.001; CRP: controls 0.6±1.3 mg/L, ECMO 31±22 mg/L, P&lt;.001.</td>
<td>Energy needs not increased in neonates with ECMO, in spite of increased inflammation &amp; mortality</td>
</tr>
<tr>
<td>Jaksic²⁰ 2001 Level III</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Neonates (N=10)</td>
<td>PN with 80-110 kcal/kg/d, protein 0.5-2 g/kg/d, fat emulsion 1-4 g/kg/d, 10-20% dextrose; repeated measures of respiratory gas exchange over 1-30 d of life during ECMO</td>
<td>REE 57±11 kcal/kg/d (range 38-80) PN with 75±25 kcal/kg/d (range 10-111)</td>
<td>Energy requirement for growth up to 45% &gt; REE, with wide variation over time &amp; among neonates</td>
</tr>
<tr>
<td>Cilley¹³ 1988 Level III</td>
<td></td>
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CRP, C reactive protein; IL-6, interleukin-6; PN, parenteral nutrition; REE, resting energy expenditure
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Table 2. Nutrition Support Recommendations in Neonates Supported with Extracorporeal Membrane Oxygenation (ECMO)

<table>
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<tr>
<th>Guideline Recommendations</th>
<th>Grade</th>
</tr>
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<tbody>
<tr>
<td>1. Nutrition support should be initiated expeditiously in neonates treated with ECMO.</td>
<td>D</td>
</tr>
<tr>
<td>2. Neonates treated with ECMO have protein requirements of up to 3 g/kg/d.</td>
<td>D</td>
</tr>
<tr>
<td>3. Energy requirements in neonates treated with ECMO are equivalent to healthy subjects.</td>
<td>D</td>
</tr>
<tr>
<td>4. Enteral feedings should be initiated when the patient on ECMO has clinically stabilized.</td>
<td>D</td>
</tr>
</tbody>
</table>

Grade D - at least 1 grade III investigation (nonrandomized cohort with contemporaneous controls)
ONE IN THREE
PEOPLE IN LOUISIANA
WILL DIE FROM HEART DISEASE
Get the facts at heart.org

2 FOR 3
CROISSAN'WICH™
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BUDDER KING
Final Thoughts

• Dietitian should have an active daily role with the care team
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• Start early enteral nutrition within 24-36 hours of initiation of ECMO with its contribution to total nutrition determined on an individual patient basis
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• Protocols for initiating and advancing nutrition may lead to more optimal nutritional delivery
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• Protocols for initiating and advancing nutrition may lead to more optimal nutritional delivery

• Further research is needed to determine optimal nutrition in patients receiving ECMO support
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