The Role of Parenteral Nutrition for Critically Ill Children

Canadian Critical Care Forum

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No Financial Disclosure
Nutrition in ICU

• Malnutrition in common in critically ill children
• Impaired immune function
• Increased infection
• Increased morbidity
• Longer intervals of care (ICU/Hospital LOS)
• Increased mortality
Benefits of Enteral Nutrition

• Attenuates systemic inflammation and immune response
• Improved GI mucosal integrity and function
• Reduced bacterial translocation
  – Maintain normal gut flora
• Lower incidence of MODS
• Improved wound healing
Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Pediatric Critically Ill Patient: Society of Critical Care Medicine and American Society for Parenteral and Enteral Nutrition

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“On the basis of observational studies, we recommend EN as the preferred mode of nutrient delivery to the critically ill child.”
Challenges to Optimal Enteral Nutrition in a Multidisciplinary Pediatric Intensive Care Unit

Mehta NM, et al. JPEN. 2010;34:38-45
Barriers to Adequate Nutrition in Critically Ill Children

Prevalence of risk factors for not achieving full EER, percentage of patients (%)

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Probability of not reaching EER</th>
<th>Days in PICU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid resusc</td>
<td>1.00</td>
<td>0</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>0.75</td>
<td>10</td>
</tr>
<tr>
<td>Large</td>
<td>0.50</td>
<td>20</td>
</tr>
<tr>
<td>Vomiting</td>
<td>0.25</td>
<td>30</td>
</tr>
<tr>
<td>Abdominal</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Diarrhea</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Cardiac</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Procedure</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Surgical</td>
<td>0.007</td>
<td></td>
</tr>
<tr>
<td>Imaging</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>Extubation</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Cooling</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>0.10</td>
<td></td>
</tr>
</tbody>
</table>


The Origins of Parenteral Nutrition

Robert Elman, 1897-1956
Under Which Conditions Should PN Be Used?

Consensus Recommendation

**Neonatal**

1C: Consider PN for neonates in the critical care setting, regardless of diagnosis, when EN is unable to meet energy requirements for energy expenditure and growth.

**Pediatric**

Not applicable.

**Adult**

PN should be initiated when EN is not functional or cannot be accessed or when nutrient needs to provide for growth are greater than that which can be provided through oral intake or EN supplementation.

Question 10: Which patients are appropriate for home PN therapy?

**Neonatal**

PN is indicated for neonates in the critical care setting when EN is unable to meet energy requirements for energy expenditure and growth.

**Pediatric**

PN for children is not indicated.

**Adult**

PN for adults is not indicated.

**References**

Patricia Worthington, MSN, RN, CNSC⁴; Jane Balint, MD²; Matthew Bechtel, MD, FACP, FACC, FACG¹; Angela Bingham, PharmD, BCPS, BCNSP, BCCCP⁴; Lingtal-Neander Chan, PharmD, BCNSP, CNSC, FACN⁵; Sharon Durfee, RPh, BCNSP⁶; Andrea K. Jevnn, RD, LD, CNSC⁶; Ainsley Malone, MS, RD, CNSC, FAND, FASPEN⁸; Maria Mascarenhas, MBBS; Daniel T. Robinson, MD⁴; and Beverly Holcombe, PharmD, BCNSP, FASHP, FASPEN¹¹

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journals.sagepub.com/home/pen

• No difference in central-line related complications
• Similar rates of 30-day complication rates and 90-day mortality
• Higher incidence of infections in PN group
  (14.1% vs 6.4%, p=0.01)
Trial of the Route of Early Nutritional Support in Critically Ill Adults

**30 day mortality**

Intervention: 33.1%
Control: 34.2%

**Infectious complications**

Intervention: 0.22
Control: 0.21

**90 day mortality**

Intervention: 37.3%
Control: 39.1%

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Early versus Late Parenteral Nutrition in Critically Ill Adults

A Discharge from ICU

Cumulative Proportion Discharged from ICU (%)

Days after Randomization

Late initiation
Early initiation

No. at Risk
Late initiation 2328 574 291 122
Early initiation 2312 646 342 147

2328 1399 913 655 436 313
2312 1438 975 736 517 371
Early versus Late Parenteral Nutrition in Critically Ill Children

Tom Fivez, M.D., Dorian Kerklaan, M.D., Dieter Mesotten, M.D., Ph.D., Sascha Verbruggen, M.D., Ph.D., Pieter J. Wouters, M.Sc., Ilse Vanhorebeek, Ph.D., Yves Debaveye, M.D., Ph.D., Dirk Vlasselaers, M.D., Ph.D., Lars Desmet, M.D., Michael P. Casaer, M.D., Ph.D., Gonzalo Garcia Guerra, M.D., Jan Hanot, M.D., Ari Joffe, M.D., Dick Tibboel, M.D., Ph.D., Koen Joosten, M.D., Ph.D., and Greet Van den Berghe, M.D., Ph.D.
# PEPaNIC Study – Primary Outcome

## ICU-related Infection

<table>
<thead>
<tr>
<th></th>
<th>Late</th>
<th>Early</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL</td>
<td>18.5%</td>
<td>10.7%</td>
</tr>
<tr>
<td>Airway</td>
<td>8.4%</td>
<td>4.2%</td>
</tr>
<tr>
<td>Blood borne</td>
<td>3.2%</td>
<td>1.4%</td>
</tr>
</tbody>
</table>

7.8% Absolute Risk Reduction
[95% CI 4.2 – 11.4%]

## ICU Length of Stay

<table>
<thead>
<tr>
<th></th>
<th>Late</th>
<th>Early</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6.5 ± 0.4</td>
<td>9.2 ± 0.8</td>
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</table>
PEPaNIC Study

- Overfeeding?
- Unexpectedly high rate
- Time to infection
1. Guidelines on Paediatric Parenteral Nutrition of the European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the European Society for Clinical Nutrition and Metabolism (ESPEN), Supported by the European Society of Paediatric Research (ESPR)


*Dr. von Hauner Children’s Hospital, Ludwig-Maximilians-University of Munich, Germany; †Hopital Necker-Enfants Malades, Paris, France; ‡Meyer Children’s Hospital, Haifa, Israel

Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Pediatric Critically Ill Patient: Society of Critical Care Medicine and American Society for Parenteral and Enteral Nutrition

Mehta NM et al. JPEN J Parenter Enteral Nutr. 2017;41:706-742

Real Life Practice

156 ICUs, 52 Countries, 6 Continents

Kerklaan. Peds Crit Care Med 2016; 17: 10-18
Survey Results

- 55% start ≤ 24 hours
- 3.5% after 7 days

**EN supplementation**

- 18% if insufficient
- 7.5% never used if EN provided

- 50% if EN ≤ 50% target
- 24% if EN ≤ 50% target

Kerklaan. Peds Crit Care Med 2016; 17: 10-18
How Much PN in Being Used?

PN used in ~30% of pts
  – 8.8% Exclusively
  – 21% EN + PN

• PN + EN
  – 52.2% prescribed energy
  – 61.2% prescribed protein

Protein Balance in Critical Care

- Increase protein catabolism and turnover
- Amino acids mobilized from skeletal muscle stores
- Gluconeogenesis and inflammation
- Net negative protein balance
- Muscle weakness, functional disability, morbidity
- Higher protein delivery required (compared to healthy controls)
Adequate enteral protein intake is inversely associated with 60-d mortality in critically ill children: a multicenter, prospective, cohort study

Nilesh M Mehta, Lori J Bechard, David Zurakowski, Christopher P Duggan, and Daren K Heyland

- Protein delivery = 37 ± 38% of prescribed
- Linear relationship between protein intake and survival

Summary Points and Consensus Recommendations
From the International Protein Summit

Ryan T. Hurt, MD, PhD\textsuperscript{1,2}; Stephen A. McClave, MD\textsuperscript{2};
Robert G. Martindale, MD, PhD\textsuperscript{3}; Juan B. Ochoa Gautier, MD, FACS, FCCM\textsuperscript{4};
Jorge A. Coss-Bu, MD\textsuperscript{5}; Roland N. Dickerson, PharmD\textsuperscript{6}; Daren K. Heyland, MD, MSc\textsuperscript{7};
L. John Hoffer, MD, PhD\textsuperscript{8}; Frederick A. Moore, MD\textsuperscript{9}; Claudia R. Morris, MD\textsuperscript{10};
Douglas Paddon-Jones, PhD\textsuperscript{11}; Jayshil J. Patel, MD\textsuperscript{12}; Stuart M. Phillips, PhD\textsuperscript{13};
Saúl J. Rugeles, MD\textsuperscript{14}; Menaka Sarav, MD\textsuperscript{15}; Peter J. M. Weijs, PhD\textsuperscript{16};
Jan Wernerman, MD, PhD\textsuperscript{17}; Jill Hamilton-Reeves, PhD, RD, CSO\textsuperscript{18};
Craig J. McClain, MD\textsuperscript{2}; and Beth Taylor, DCN, RD-AP\textsuperscript{19}

“Achieving protein goals in the first week following admission to the ICU should take precedence over patient energy goals.”

Protein Delivery in PEPaNIC

- Despite increase in protein delivery
  - Increase infection and AKI requiring RRT
  - Increase mechanical ventilation, ICU/Hospital LOS

The Role of Fats

- **Omegaven®**
  - Most commonly used lipid in PN
  - Soybean derived = rich in omega (ω) 6 Fatty Acids
  - Pro-inflammatory and associated with liver dysfunction
• Reduction in Parenteral Nutrition Associated Liver Disease
  – 9 of 12 patients delisted or workup terminated for liver-small bowel transplantation
  – Reduction in hyperbilirubinemia
  – Reduction in transaminitis = lower inflammation
Conclusions

1. PN has a valuable role in the provision of adequate nutrition for critically ill children
2. Exact timing of PN remains unclear
3. Further research required to determine the optimal composition and dosing of PN macronutrients
Thank you