Nutrition Support in Critically Ill Cardiothoracic Patients

O. Natasha Povphan Peeramysdin

Department of Clinical Nutrition, Department of Pediatrics
Siriraj Hospital, Mahidol University
Outline

- Malnutrition in cardiothoracic patients
- Nutritional requirements
- Enteral Nutrition
  - Shock & EN
- Parenteral Nutrition
  - Glycemic control
  - When to add PN when EN is inadequate?
Figure 1. Cardiac Energy Metabolism.
Malnutrition Increases Morbidity & Mortality after CABG

Reeves BC et al. JACC 2003 20;42(4):668-76
Malnutrition Increases Mortality after Cardiac Surgery

Nutrition Screening in Cardiac Surgery

"Malnutrition"

**Table 1. The Etiology-Based Cardiac-Surgery-Specific Undernutrition Screening Tool (CSSUST)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Score^a</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BMI (kg/m^2)</strong></td>
<td></td>
</tr>
<tr>
<td>&gt;30</td>
<td>0</td>
</tr>
<tr>
<td>21–30</td>
<td>1</td>
</tr>
<tr>
<td>&lt;21</td>
<td>2</td>
</tr>
<tr>
<td><strong>Unintended weight loss in the past 3–6 months</strong></td>
<td></td>
</tr>
<tr>
<td>&lt;5%</td>
<td>0</td>
</tr>
<tr>
<td>5%–10%</td>
<td>1</td>
</tr>
<tr>
<td>&gt;10%</td>
<td>2</td>
</tr>
<tr>
<td><strong>Did the patient experience a decreased appetite over the past month?</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Was the patient hospitalized preoperatively?</strong></td>
<td>1</td>
</tr>
</tbody>
</table>

^a Score ≥ 2; high-risk for undernutrition, score <2; low risk for undernutrition.

BMI = body mass index.

“Good marker of stress severity”
“High nutritional risk”
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Nutritional Requirements

Energy

Indirect Calorimetry

“Gold Standard”
Nutritional Requirements

• Energy: 25-30 kcal/kg/day
  Use pre-illness weight (no edema)

or Harris-Benedict Equation (REE)
TEE = REE x stress factor x activity factor

• Protein: 1.2 - 1.5 g/kg/day
  Severe stress up to 2 g/kg/day
Total Energy Expenditure : TEE

• TEE = BEE x Activity Factor (AF) x Stress Factor (SF)
  • Activity Factor (AF)
    – On ventilator 0.7-0.9
    – Bed ridden 0.9-1.0
    – Confined to bed 1.2
    – Out of bed 1.3
  • Stress Factor (SF)
    – Major operation 1.0-1.2
    – Cancer/COPD 1.1-1.3
    – Severe infection/multiple trauma 1.3-1.5
    – Severe sepsis 1.4-1.8
    – Burns 1.5-2.0
<table>
<thead>
<tr>
<th>Macronutrient targets in patients with acute kidney injury</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy (total calories)</strong></td>
</tr>
<tr>
<td>Total calories</td>
</tr>
<tr>
<td>Carbohydrates</td>
</tr>
<tr>
<td>Fat</td>
</tr>
<tr>
<td><strong>Protein</strong></td>
</tr>
<tr>
<td>No catabolism, no RRT</td>
</tr>
<tr>
<td>Moderate catabolism, on RRT</td>
</tr>
<tr>
<td>Severe catabolism, on RRT (CRRT or SLED)</td>
</tr>
<tr>
<td><strong>Route of nutrition</strong></td>
</tr>
<tr>
<td>No catabolism, no RRT</td>
</tr>
<tr>
<td>Moderate catabolism, on RRT</td>
</tr>
<tr>
<td>Severe catabolism, on RRT (CRRT or SLED)</td>
</tr>
</tbody>
</table>

BW, body weight; CRRT, continuous renal replacement therapy; RRT, renal replacement therapy; SLED, aUsual body weight when available or ideal body weight.
Standard amino acid PN should be used in AKI
– Inadequate evidence to support EAA PN

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcome</th>
<th>Abel et al(^{9})</th>
<th>Leonard et al(^{17})</th>
<th>Feinstein et al(^{18})</th>
<th>Feinstein et al(^{19})</th>
<th>Mirtallo et al(^{20})</th>
<th>Waitzberg et al(^{21})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery from acute renal failure</td>
<td>EAA/HD group</td>
<td>21/28(^{a}) (75)</td>
<td>No data</td>
<td>7/11 (64)</td>
<td>3/5 (60)</td>
<td>12/24(^{b}) (50)</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td>SAA/HD group</td>
<td>No data</td>
<td>4/12 (33)</td>
<td>0/6 (0)</td>
<td>11/21(^{b}) (52)</td>
<td>No data</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HD group</td>
<td>11/25(^{a}) (44)</td>
<td>No data</td>
<td>2/7 (29)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survival at end of hospitalization</td>
<td>EAA/HD group</td>
<td>17/28 (61)</td>
<td>6/11 (55)</td>
<td>6/11 (55)</td>
<td>2/5 (40)</td>
<td>18/24 (75)</td>
<td>13/17 (76)</td>
</tr>
<tr>
<td></td>
<td>SAA/HD group</td>
<td>3/12 (25)</td>
<td>0/6 (0)</td>
<td></td>
<td>13/21 (62)</td>
<td></td>
<td>11/17 (65)</td>
</tr>
<tr>
<td></td>
<td>HD group</td>
<td>10/25 (40)</td>
<td>5/9 (56)</td>
<td>2/7 (29)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### VAD Patients

**Table 1. Nutrition Recommendations for Ventricular Assist Device (VAD) Patients**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy requirements</strong></td>
<td>30–35 kcal/kg OR (RMR) + 15%–25% minimal, physical activity and additional 10%–20% for hypermetabolism[^73^]</td>
</tr>
<tr>
<td><strong>Protein needs</strong></td>
<td>1–1.5 g/kg[^13^]</td>
</tr>
<tr>
<td><strong>Sodium</strong></td>
<td>2 g sodium[^78^,^79^]</td>
</tr>
<tr>
<td><strong>Fluid</strong></td>
<td>1.5–2.0 L[^80^,^81^]</td>
</tr>
<tr>
<td><strong>Oral diet</strong></td>
<td>Small/frequent meals. Encourage protein intakes for meeting metabolic demand[^78^,^82^]</td>
</tr>
<tr>
<td><strong>Enteral nutrition</strong></td>
<td>Consider feeding tube placement into small intestine. Hypo-osmolar, fiber-free formula, concentrated (ie, 1.5 kcal/mL[^62^])</td>
</tr>
<tr>
<td><strong>Vitamin/mineral supplementation</strong></td>
<td>B vitamin: supplementation if poor oral intakes or known deficiency[^32^,^33^]</td>
</tr>
<tr>
<td></td>
<td>Vitamin D: supplementation if known deficiency[^41^,^43^]</td>
</tr>
<tr>
<td></td>
<td>Zinc: supplementation if known deficiency[^44^,^45^]</td>
</tr>
</tbody>
</table>

IBW, ideal body weight; RMR, resting metabolic rate.

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[^13^]: 1–1.5 g/kg
[^78^]: 2 g sodium
[^79^]: 1.5–2.0 L
[^80^]: Small/frequent meals
[^81^]: Consider feeding tube placement into small intestine
[^32^]: B vitamin
[^33^]: supplementation if poor oral intakes or known deficiency
[^41^]: Vitamin D
[^43^]: supplementation if known deficiency
[^44^]: Zinc
[^45^]: supplementation if known deficiency

Wernicke's Encephalopathy
- Nystagmus & ophthalmoplegia
- Ataxia
- Confusion

Dry Beriberi

Wet Beriberi

Korsakoff’s syndrome
- Amnesia, apathy

Wernicke’s Encephalopathy
- Nystagmus & ophthalmoplegia
- Ataxia
- Confusion
## Thiamine

### Table 3. Mechanisms Contributing to Thiamin Deficiency in Heart Failure Patients

- Urinary wasting from diuretics or dialysis
- Diarrhea
- Dietary inadequacy
- Malabsorption syndromes
- Gastroplasty/gastric bypass surgery
- Alcoholism
- Thiaminases in certain foods (eg, tannins in tea)
- Magnesium deficiency
- Hyperthyroidism

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**Rx**: Thiamine 100 mg IV daily for several days then 10-30 mg PO daily

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Figure 1. Schematic representation of the intestinal villus countercurrent exchange of oxygen. Oxygen diffuses from the artery to the villous veins throughout their course to the tip of the villus. This results in a descending gradient of $PO_2$ from the base of the villus to the tip.
Gut as the motor of multi-organ failure (MOF)

Thibault et al.
Intensive Care Med (2011) 37:35–45
Early EN Improves Outcomes in ICU Patients on Vasopressors


EN is Possible (but maybe inadequate) in Pts with Shock

### Recommendations for enteral feeding in patients at high risk for ischemic bowel

- **Start at low rate (20 ml/h)**

<table>
<thead>
<tr>
<th>Closely monitor for potential signs of gastrointestinal intolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enteral formula selection</td>
</tr>
<tr>
<td>Isosmolar</td>
</tr>
<tr>
<td>Low residue with no added fiber</td>
</tr>
<tr>
<td>Foods should be held with the development of</td>
</tr>
<tr>
<td>Hypotension (sustained &lt;70 mm Hg)</td>
</tr>
<tr>
<td>Need for accelerated doses of pressor agents</td>
</tr>
<tr>
<td>Increasing ventilatory support</td>
</tr>
<tr>
<td>Worsening signs of gastrointestinal intolerance</td>
</tr>
</tbody>
</table>

**Polymeric**

<table>
<thead>
<tr>
<th>Clinical signs or symptoms</th>
<th>Increasing gastric residual volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acute abdominal pain</td>
</tr>
<tr>
<td></td>
<td>Increasing intra-abdominal pressure &gt;15 mm Hg</td>
</tr>
<tr>
<td></td>
<td>Abdominal distension</td>
</tr>
<tr>
<td></td>
<td>Ileus (suddenly silent abdomen or high-pitched metallic bowel sounds)</td>
</tr>
<tr>
<td></td>
<td>Cessation of passing gas and stooling</td>
</tr>
<tr>
<td></td>
<td>Oliguria</td>
</tr>
<tr>
<td></td>
<td>Shock</td>
</tr>
<tr>
<td>Laboratory</td>
<td>Arterial plasma lactate ↑ (late nonspecific sign)</td>
</tr>
<tr>
<td></td>
<td>Acidosis</td>
</tr>
<tr>
<td></td>
<td>Leukocytosis</td>
</tr>
<tr>
<td>Radiological signs</td>
<td>Gastric partial pressure of carbon dioxide ↑</td>
</tr>
<tr>
<td></td>
<td>Dilated and thickened bowel loops</td>
</tr>
<tr>
<td></td>
<td>Pneumatosis intestinalis</td>
</tr>
<tr>
<td></td>
<td>Air in the portal vein</td>
</tr>
<tr>
<td></td>
<td>Air in the peritoneal space</td>
</tr>
</tbody>
</table>

Berger et al.  
JPEN 2009  
33:702
Guidelines: EN in Critical Illness

- EN is preferred over PN
- Early EN within 24-48 hours of admission
  - Advance to goal over 48-72 hours

- Canadian clinical practice guidelines for nutrition support in mechanically ventilated, critically ill adult patients. JPEN 2003 27:355–373
- Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: SCCM and ASPEN. Crit Care Med 2009 37:1757–1761
Guidelines: EN in Critical Illness

• In the setting of hemodynamic compromise, EN should be withheld until the patient is fully resuscitated and/or stable.

• Either gastric or small bowel feeding is acceptable in the ICU setting.

Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: SCCM and ASPEN. Crit Care Med 2009 37:1757–1761
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The New England Journal of Medicine

VOLUME 345
NOVEMBER 8, 2001
NUMBER 19

INTENSIVE INSULIN THERAPY IN CRITICALLY ILL PATIENTS

GREET VAN DEN BERGHE, M.D., PH.D., PIETER WOUTERS, M.SC., FRANK WEEKERS, M.D., CHARLES VERWAEST, M.D., FRANS BRUYNINCKX, M.D., MIECH SCHETZ, M.D., PH.D., DIRK VLAESLAERS, M.D., PATRICK FERDINANDE, M.D., PH.D., PETER LAUERS, M.D., AND ROGER BOUILLON, M.D., PH.D.

• Leuven study
• 80-110 vs. 180-200 mg/dl
• 63% cardiac surgery pts
• Median ICU LOS 3 days
• Most received TPN / dextrose

NEJM 2001; 345:1359-67
Tight Glycemic Control in Diabetic Coronary Artery Bypass Graft Patients Improves Perioperative Outcomes and Decreases Recurrent Ischemic Events
Harold L. Lazar, Stuart R. Chipkin, Carmel A. Fitzgerald, Yusheng Bao, Howard Cabral and Carl S. Apstein

260 mg/dL

138 mg/dL

* P<0.0001
GIK group:
Lower incidence of AF (16.6% vs. 42%)
Shorter LOS (6.5d vs. 9.2d)
Less recurrent ischemia (5% vs. 19%)
Fewer wound infection (1% vs. 10%)

Intensive versus Conventional Glucose Control in Critically Ill Patients

The NICE-SUGAR Study Investigators*

Intensive group:
More hypoglycemia (6.8% vs. 0.5%)
More deaths (27.5% vs. 24.9%)

81-108 mg/dL

<180 mg/dL
>180 mg/dl increases deaths particularly with TPN

80-110 mg/dl increases hypoglycemia & deaths

120-180 mg/dl is a reasonable goal

JCEM 94: 3163–3170, 2009
The Society of Thoracic Surgeons Practice Guideline Series: Blood Glucose Management During Adult Cardiac Surgery

VII. Glycemic Control in the ICU

Recommendation: Class I

- Patients with and without diabetes with persistently elevated serum glucose (> 180 mg/dL) should receive IV insulin infusions to maintain serum glucose < 180 mg/dL for the duration of their ICU care (level of evidence = A).
- All patients who require ≥ 3 days in the ICU because of ventilatory dependency or requiring the need for inotropes, intra-aortic balloon pump, or ventricular assist device support, anti-arrhythmics, dialysis, or continuous veno-venous hemofiltration should have a continuous insulin infusion to keep blood glucose ≤ 150 mg/dL, regardless of diabetic status (level of evidence = B).
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Route of Nutrition Support

Functional GI tract?

Yes → Enteral Nutrition
   → Adequate
   → Inadequate

No → Parenteral Nutrition
   Add supplemental PN?
   When and how?
EN is often inadequate in the ICU

Berger et al. JPEN 2009 33:702
Negative Energy Balance in the ICU Is Associated with Morbidity
Early versus Late Parenteral Nutrition in Critically Ill Adults

Michael P. Casaer, M.D., Dieter Mesotten, M.D., Ph.D., Greet Hermans, M.D., Ph.D., Pieter J. Wouters, R.N., M.Sc., Miet Schetz, M.D., Ph.D., Geert Meyfroidt, M.D., Ph.D., Sophie Van Cromphaut, M.D., Ph.D., Catherine Ingels, M.D., Philippe Meersseman, M.D., Jan Muller, M.D., Dirk Vlasselaers, M.D., Ph.D., Yves Debaveye, M.D., Ph.D., Lars Desmet, M.D., Jasperina Dubois, M.D., Aime Van Assche, M.D., Simon Vanderheyden, B.Sc., Alexander Wilmer, M.D., Ph.D., and Greet Van den Berghe, M.D., Ph.D.

- EPaNIC (Leuven)
- 61% cardiac sx
- N = 4,640
- > 80% SICU
Early PN group:
- More ICU infection (22.8% vs. 26.2%)
- Longer MV & RRT time
- Higher cost
Optimisation of energy provision with supplemental parenteral nutrition in critically ill patients: a randomised controlled clinical trial

Heidegger et al.
Lancet 2013; 381: 385–93

Claudia Paula Heidegger, Mette M Berger, Séverine Graf, Walter Zingg, Patrice Darmon, Michael C Costanza, Ronan Thibault, Claude Pichard

- “Swiss Trial”
- N = 305
- 14% cardiac surgery
- 30% SICU 70% MICU
Supplemental PN group:
Less nosocomial infection (27% vs. 38%)
Shorter MV time in patients without infection
What is different?

EPaNIC (PN bad)
• Patients are less sick
  – EN intolerance not established
  – 61% elective cardiac sx
  – ICU LOS<3d in 50%

Swiss trial (PN good)
• Patients are sicker
  – Established EN intolerance at d4 before starting PN
  – 14% elective cardiac sx
  – Expected ICU LOS>5d, actual mean LOS 13 days
What is different?

EPaNIC (PN bad)
• Patients are less sick
  – EN intolerance not established
  – 61% elective cardiac sx
  – ICU LOS<3d in 50%
• Possible overfeeding
  – Early hypertonic glucose load on first day

Swiss trial (PN good)
• Patients are sicker
  – Established EN intolerance at d4 before starting PN
  – 14% elective cardiac sx
  – Expected ICU LOS>5d, actual mean LOS 13 days
• Less overfeeding
  – Indirect calorimetry (IC) in 2/3 of pts on day3
Uncomplicated cardiac surgery, ICU stay <3-4d
→ Early EN, no PN

Complicated cardiac surgery, ICU >5d, malnourished
→ Early EN
→ Add PN d5-7 if EN inadequate

Cannot use GI tract, no enteral nutrition
→ Not malnourished, start PN on d5-d7
→ Malnourished, start PN right away

Take Home Messages

• Malnutrition increases mortality
• Use appropriate energy & protein goals to decrease complications (over- & under-feeding)
• Early EN during shock improves outcomes but requires monitoring
• In complicated malnourished patients, when EN is inadequate, supplemental PN on d5-7 may improve outcomes
• Optimal glycemic control (120-180 mg/dl) while on PN improves outcomes
Randomised trial of glutamine, selenium, or both, to supplement parenteral nutrition for critically ill patients

No benefits of glutamine or Se in mortality or infection except patients receiving >5d of Selenium

A Randomized Trial of Glutamine and Antioxidants in Critically Ill Patients

Increased mortality in glutamine group
Thank You
For Your Attention
Both EN and PN have a role in critically ill cardiac surgery patients.