Nutrition Support

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Overview

- Why?
- When?
- How much?
- What route?
- Fancy stuff: enhanced nutrition
Advantages of Nutrition

- Decreased catabolism
- Improved wound healing
- Improved immune function
- Decreased infection risk (mainly in enterally-fed)
Why Nutritional Status is Important

- Daley, *JACS*, 1997
- 87078 major non-cardiac operations at 44 VA medical centers 1991-1993
- Serum albumin: best single indicator of postoperative complications

Table 2. Order of Entry of Patient Predictor Variables for Postoperative Morbidity: All Operations

<table>
<thead>
<tr>
<th>Order</th>
<th>Variable</th>
<th>$\beta$ Coefficient</th>
<th>Odds ratio</th>
<th>95% CI of OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Albumin (g/dL)</td>
<td>−0.283</td>
<td>0.753</td>
<td>0.72–0.79</td>
</tr>
<tr>
<td>2</td>
<td>ASA class</td>
<td>0.269</td>
<td>1.308</td>
<td>1.26–1.36</td>
</tr>
<tr>
<td>3</td>
<td>Complexity score</td>
<td>0.505</td>
<td>1.657</td>
<td>1.61–1.70</td>
</tr>
<tr>
<td>4</td>
<td>Emergency operation</td>
<td>0.522</td>
<td>1.685</td>
<td>1.58–1.79</td>
</tr>
<tr>
<td>5</td>
<td>Functional status</td>
<td>0.262</td>
<td>1.300</td>
<td>1.25–1.36</td>
</tr>
<tr>
<td>6</td>
<td>Ventilator dependent</td>
<td>0.808</td>
<td>2.244</td>
<td>1.87–2.69</td>
</tr>
<tr>
<td>7</td>
<td>Wound infection</td>
<td>0.236</td>
<td>1.266</td>
<td>1.19–1.35</td>
</tr>
<tr>
<td>8</td>
<td>History of COPD</td>
<td>0.211</td>
<td>1.235</td>
<td>1.17–1.30</td>
</tr>
<tr>
<td>9</td>
<td>Hematocrit ≤ 38%</td>
<td>0.211</td>
<td>1.235</td>
<td>1.18–1.29</td>
</tr>
<tr>
<td>10</td>
<td>Age</td>
<td>0.015</td>
<td>1.015</td>
<td>1.01–1.02</td>
</tr>
<tr>
<td>11</td>
<td>WBC &gt; 11,000/µL</td>
<td>0.188</td>
<td>1.206</td>
<td>1.15–1.27</td>
</tr>
<tr>
<td>12</td>
<td>General surgery*</td>
<td>0.681</td>
<td>1.976</td>
<td>1.83–2.13</td>
</tr>
<tr>
<td>13</td>
<td>Plastic surgery*</td>
<td>0.852</td>
<td>2.344</td>
<td>2.13–2.85</td>
</tr>
<tr>
<td>14</td>
<td>BUN &gt; 40 mg/dL</td>
<td>0.560</td>
<td>1.434</td>
<td>1.30–1.58</td>
</tr>
<tr>
<td>15</td>
<td>SGOT &gt; 40 IU/L</td>
<td>0.132</td>
<td>1.141</td>
<td>1.08–1.21</td>
</tr>
<tr>
<td>16</td>
<td>Platelets ≤ 150,000/µL</td>
<td>0.257</td>
<td>1.292</td>
<td>1.19–1.40</td>
</tr>
<tr>
<td>17</td>
<td>Impaired sensorium</td>
<td>0.251</td>
<td>1.286</td>
<td>1.19–1.39</td>
</tr>
<tr>
<td>18</td>
<td>Rest pain/gangrene</td>
<td>0.192</td>
<td>1.212</td>
<td>1.12–1.31</td>
</tr>
<tr>
<td></td>
<td>Intercept</td>
<td>−5.181</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Surgical Site Modulates Risk of Malnutrition

Kudsk, *JPEN*, 2003
- Retrospective
- N=526
- Similar trends for ICU stay, mortality

![Graph showing incidence of complications vs. serum albumin for different organs.](image)
When?

- Early is better
- Early is safe
Early is Better/ Safe
Moore, *J Trauma*, 1986

- N = 75; s/p emergent laparotomy for trauma
- Randomized to jejunostomy feeding at 18h vs. starvation to POD#5
- Overall complication rate not different
- Septic morbidity higher in control
  - Seven intra-abd abscesses vs. three
  - Pneumonia in two vs. none
Early is Better/ Safe

  - Meta-analysis of 15 RCTs (N=753)
  - Early (<36h postop/admit) nutrition:
    - Lower infections (RR=0.45%)
    - Shorter hospital stay by 2.2 days

  - Meta-analysis of 11 RCTs (N=837)
  - Randomized to NPO or early (within 24h postop) feeding (jejunal or by mouth) following GI tract resection (mostly lower)

RCT = Randomized Controlled Trial
How Much?

- Types of substrates
- Estimating daily energy needs
- Caloric/protein requirements
# Types of Substrates

<table>
<thead>
<tr>
<th></th>
<th>VO$_2$ [L/g]</th>
<th>VCO$_2$ [L/g]</th>
<th>RQ</th>
<th>Energy [kcal/g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipid</td>
<td>2.0</td>
<td>1.4</td>
<td>0.7</td>
<td>9.1</td>
</tr>
<tr>
<td>Protein</td>
<td>0.96</td>
<td>0.78</td>
<td>0.8</td>
<td>4.0</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>0.74</td>
<td>0.74</td>
<td>1.0</td>
<td>3.7</td>
</tr>
</tbody>
</table>

VO$_2$ = oxygen required; VCO$_2$ = carbon dioxide produced; RQ = respiratory quotient
Predicting Daily Energy Needs

- **Harris-Benedict: BEE (resting & fasted state)**
  - 239 white people studied in 1919
  - Men: $66 \times 1 + (13.7 \times wt) + (5.0 \times ht) - (6.7 \times age)$
  - Women: $655 + (9.6 \times wt) + (1.8 \times ht) - (4.7 \times age)$

- **Simplification: 25 \times wt** (e.g., 70 kg \times 25 = 1750 kcal/day)

- **REE (resting, not fasting) = 1.2 \times BEE \times \alpha**
  - Fever: $\alpha = 1.1$ for each degrees centigrade above 37
  - Mild Stress (long bone fracture, mild trauma): $\alpha = 1.2$
  - Severe Stress (multi-organ trauma): $\alpha = 1.6$
  - Burns >40% TBSA: $\alpha = 2.0$

BEE = basal energy expenditure; wt = ideal body weight in kg; ht = height in inches
Indirect Calorimetry

- Indirectly measures energy use by measuring $O_2$ use & $CO_2$ production
- $REE = (3.9 \times VO_2) + (1.1 \times VCO_2) - 61$
- $VO_2$ & $VCO_2$ measured over 30-60 minutes using metabolic carts → extrapolated to 24h
What Fuel Mixture?

- NPC = non-protein calories
  - Carbohydrates: 60-70% total calories
    - Primary fuel of CNS, RBCs, WBCs, renal medulla
    - Be aware of high RQ (= 1.0 vs. 0.7 for fat) generates a lot of CO$_2$ during metabolism
  - Lipids: 10-25% total calories
- Protein: usually <20% of total calories

CNS = central nervous system; RBCs = red blood cells; WBCs = white blood cells
Protein Requirements

- Normally, 1 g protein/kg/day = 0.16g N\textsubscript{2}/kg/day
- Hypercatabolic state
  - up to 2g protein/kg/day = 0.32g N\textsubscript{2}/kg/day
  - especially important in burns
- Goal: positive nitrogen balance
  - majority of nitrogen derived from protein excreted in urine as urea
  - measure urinary urea nitrogen (UUN)
- \(N_2\) balance = \(N_2\) intake - UUN - 4
  - non-urea nitrogen loss estimated at 4 g
  - UUN not helpful if creatinine clearance < 50
- Serum markers: prealbumin (\(t_{1/2} = 1.9\) days compared to 21 days for albumin)
What Route?

- Use the gut if it works
- Enteral
- Parenteral
Enteral Feeds

- Preferred route
- Contraindications: bowel obstruction, gut ischemia/high-dose vasopressors
- Nonsurgical
  - Salem sumps (14-16 Fr*) vs. Dobhoff tubes (8 Fr)
  - Gastric vs. duodenal: no difference in aspiration (Strong, JPEN, 1992)
- Surgical
  - Gastrostomy, jejunostomy
  - NCJ: needle-catheter jejunostomy: 16-gauge tube \( \rightarrow \) limits type of feed (i.e., low-fiber content)

*Recall: diameter in mm = (size in French)/\( \pi \) \( \approx \) (size in French/3)
Benefits of Enteral Route

  - 53 trauma patients randomized to enteral nutrition vs. starvation
  - 41% vs. 58% major infectious complications
  - Added bonus: shorter ICU stay

- Survival (Barr, *Chest*, 2004)
  - 200 ICU patients randomized to protocol-driven attempt to achieve target enteral nutrition vs. non-protocol
  - Risk of death 56% lower, shorter time on ventilator
Formulations

- Intact vs. elemental, i.e. whole proteins vs. peptides/amino acids
- Most formulas isocaloric (1 kcal/mL)
- “HN” = high nitrogen. Only 20% increase compared to regular
- Variations in osmolarity: (270 – 500 mOsm/L)
  - Generally, elemental and HN formulas → higher osmolarity
  - Stomach more tolerant of hyperosmolar formulas
Parenteral Nutrition (PN)

- **Advantages**
  - Rapid achievement of target administration
  - No dependence on gastrointestinal tract integrity/function

- **Disadvantages**
  - Bowel atrophy
    - Meta-analysis of 13 studies comparing isocaloric parenteral nutrition vs. enteral nutrition (EN)
    - EN: 64% relative risk for infectious complications
    - No difference in mortality, days on ventilator, hospital stay length
PN: Possible Redemption?

  - PN beneficial in subset of severely malnourished patients in terms of noninfectious complications

- Van den Berghe, *NEJM*, 2001
  - 1584 ventilated ICU patients
  - Randomized to intensive insulin Rx (glucose 80-110) vs. conventional Rx.
  - Mortality reduced 34%, sepsis 46%, renal failure required dialysis 41%, number of units of blood transfusion by 50%

![Graph showing In-Hospital Survival (%) over Days after Admission, with two lines representing Intensive treatment and Conventional treatment.]
Fancy Stuff: Enhanced Nutrition

- Glutamine
- ω-3 fatty acids
- Arginine
Glutamine

- Primary fuel for bowel mucosa: supplementation → improved integrity?
- Conditionally essential amino acid: rapidly mobilized during stress
- Moore, *J Trauma*, 1994: 94 trauma patients randomized to immune-enhancing tube feed* vs. regular → lower multi-organ failure (0% vs. 11%) & intra-abdominal abscesses
- Mendez, *J Trauma*, 1997: 42 trauma patients randomized similarly to above → higher length of stay, ventilator days, risk of ARDS (45% vs. 18%)

ARDS = Adult Respiratory Distress Syndrome

*also had arginine, ω-3 fatty acids, nucleotides and branched-chain amino acids
ω-3 Fatty Acids

- ω-6 Fatty Acids
  - Predominant in vegetable oils, commonly used for enteral/parenteral nutrition formulas
  - Precursors for inflammatory mediators (eicosanoids)

- ω-3 Fatty Acids
  - Found in fish & canola oil*
  - Shown to decrease NF-κB (pro-inflammatory transcription factor) translocation into nucleus
  - Heller, *Crit Care Med*, 2006: mortality reduced from 19% (predicted) to 12% in 600 ICU patients; antibiotic use decreased 26%
Arginine

- Not essential, but only substrate for NO synthesis by iNOS which is induced in sepsis
  - NO important in vasomotor control: insufficient NO $\Rightarrow$ shunting
  - Arginine supplementation in pig model of sepsis $\Rightarrow$ PA pressures did not rise, and flow to liver increased
- Bertolini, *Intensive Care Med*, 2003: reduced septic patients’ mortality from 44% to 14% (N=237)
- Controversial: further analysis of patients in studies who actually received arginine (as opposed to patients who were intended to receive it) appear to show higher mortality

iNOS = inducible Nitric Oxide Synthase; PA = pulmonary artery
Adequate nutrition is crucial for preventing avoidable morbidity/mortality. Enteral nutrition is preferred & is safe early. Parenteral nutrition should be reserved for the severely malnourished (includes intolerance/inability to enterally feed >5 days). Enhanced nutrition, while promising, needs further studies.
Severe Trauma

From: Practice Guidelines for Nutritional Support of the Trauma Patient, J Trauma, 2004