Hospital Nutrition
Nutritional Support of Hospitalized Patients

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OBJECTIVES

Review assessment and management of nutritional risk for hospitalized patients based upon evaluation of inquiry

Q.1 Does the patient need to be fed? Is the patient malnourished or at nutritional risk?

Q.2 If yes, when should feeding begin?

Q.3 If feeding is indicated now, how should the patient be fed?

Case study of EN and PN nutrition support
Q.1 Does the patient need to be fed?

☑ Is the patient malnourished or at nutritional risk?
Subjective Global Assessment*

**History**
- Wt. loss over past 6 mos, and past 2 wks
- Change in dietary intake
- Gut symptoms
- Functional capacity
- Co-morbid disease related to nutritional needs

**Examination**
- Loss of SQ fat
- Muscle wasting
- Edema (dependent)
- Ascites
- Mucosal lesions
- Skin lesions
- Hair loss/change

*SGA Rating*: (1) Well nourished, (2) Moderately - or suspected of being - malnourished, and (3) Severely malnourished.

Prevalence of Protein-Calorie Malnutrition in Hospitalized Patients

**Criterion:** subjective global assessment (SGA)

<table>
<thead>
<tr>
<th>Patient Group</th>
<th>(n)</th>
<th>(%)*</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical At Random</td>
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<td>48</td>
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<tr>
<td>Medical At Random</td>
<td>251</td>
<td>44</td>
<td>2</td>
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<tr>
<td>Medical On Admission</td>
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<td>Australian Hospital Survey At Random</td>
<td>819</td>
<td>36</td>
<td>4</td>
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<tr>
<td>Brazilian National Hospital Survey</td>
<td>Cross-sectional Multi-centered</td>
<td>4000</td>
<td>48</td>
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</tbody>
</table>

Nutrition Assessment

- **Hospitalized patients**
  - Severe risk of worse outcome greater when 10% to 15% wt. loss occurs within 6 months
    - *Clin Nutr* 2006;25:180

- **Cardiac surgery**
  - Patients with preoperative unintentional wt. loss of > 10%, or BMI < 21, had greater risk of infections and prolonged ICU stay
    - *Am J Clin Nutr* 2008;87:1656
Assessment of Nutritional Risk

Body weight (%)

0 10 20 30 40 50 60 70 80 90 100

Fat

(160,000 calories)

Fat assessed by:

TSF

Protein assessed by:

AMC

CHI

4.5

Albumin

Pre-albumin

0.3

Transferrin

1.5

6.7

Body cell mass

(30,000 calories)

Skeletal muscle

Viscera, etc

Plasma protein

Extracellular

Skeleton
Nutrition Assessment

Wt Loss (per 6 mos)

Case 1: 28 y.o. F, anorexia with amenorrhea, BMI 16.0, albumin 4.0 g/dl, no recent weight loss. Dx: cholecystitis. Is she malnourished?

Case 2: 68 y.o. M with acute abdominal pain, BMI 28, albumin 4 g/dl. Now one week later, post-op AAA repair in SICU, albumin 3.0 g/dl. Is he malnourished?
Nutritional Parameters and Post-op Complications

• **Pre-op**: Nutritional parameters collected in 64 patients before major surgery for head and neck cancer:
  - % weight loss
  - Lymphocyte count
  - % ideal weight
  - Nutritional index
  - Albumin
  - Body fat and lean mass

• **Post-op**: Recent weight loss $\geq 10\%$ was the only predictor for post-op complications

*Head Neck* 1997;19:419
## Metabolic Response to Illness

- **Neuroendocrine hormones**
  - ADH/aldosterone: Water and salt balance
  - Counter-regulatory hormones: Intermediary metabolism

- **Immobilization**: Protein catabolism

- **Cytokine production**: Bodily response to injury & inflammation
Cytokines and Nutritional Assessment

Cytokines (IL’s, TNF) are modulators of response to illness

- Cytokine effects
  - Anorexia
  - Physiologic stress markers
    - Fever, leukocytosis with left shift
    - Hyperglycemia
  - Hypoalbuminemia; synthesis of acute-phase proteins
  - Negative nitrogen balance
  - Redistribution of plasma Zn (↓) and Cu (↑)
Plasma Albumin

**Level affected by:**
- ✓ Rate of synthesis
- ✓ Volume of distribution
- ✓ Rate of catabolism
- ✓ Long half-life

**Effect of illness:**
- ▼
- ▲
- ▲
- (na)

**Sum:** serum level ▼
Acute-Phase Proteins After a Moderate Inflammatory Stimulus

Gabay C et al. NEJM 1999;340:448
Nutrition Assessment

Stress

Low:

Mod:
SICU, MICU

High:
CHI, Burns, MSOF, SIRS, Sepsis, Multiple Trauma

Wt Loss (per 6 mos)

High:
CHI, Burns, MSOF, SIRS, Sepsis, Multiple Trauma

(10%)

(20%)
CHI Patients: Acute-Phase Response

Nutrition: REE plus 20% and 1.5 gm protein/kg (n=62)

- **Albumin (g/dL)**
  - Days: 1-2, 3-5, 6-8, 9-11, 12-14, 15-18
  - Normal range

- **Zinc (µg/dL)**
  - Days: 1-2, 3-5, 6-8, 9-11, 12-14, 15-18
  - Normal range

- **CRP (mg/dL)**
  - Days: 1-2, 3-5, 6-8, 9-11, 12-14, 15-18
  - Normal range

ICU Hypoalbuminemia

• **Insensitive nutrition marker**
  - Albumin and prealbumin are negative acute-phase proteins

• **Prognostic value**

• **Affects interpretation of minerals and trace metals**
  - Calcium, magnesium and zinc

• **Affects drug pharmacokinetics**
  - Meds highly protein-bound with a narrow therapeutic index (Dilantin)
Nutrition Assessment

Q.1 Does the patient need to be fed?
✓ Is the patient malnourished or at nutritional risk?

Q.2 If yes, when should feeding begin?
✓ Weight loss
✓ Degree of stress
✓ Duration of NPO
Nutrition Assessment

Stress

Low:

Mod:
SICU, MICU

High:
CHI, Burns, MSOF, SIRS, Sepsis, Multiple Trauma

Wt Loss (per 6 mos)

(10%) (20%)

Case 1: 60 y.o. F, with 3 mos. failure to thrive, community acquired pneumonia. Usual wt. 66 kg, admit 60 kg, Eating poorly due to anorexia. What is your nutrition assessment?
Nutrition Assessment

Stress

Low:

Mod:
SICU, MICU

High:
CHI, Burns, MSOF, SIRS, Sepsis, Multiple Trauma

Wt Loss (per 6 mos)

(10%)

(20%)

Case 2: 60 y.o. F, with 3 mos. abdominal pain, ileus s/p resection of ischemic bowel. Usual wt. 66 kg, admit 60 kg, postop 66 kg, distended, edema, x-ray c/w ileus. What is your nutrition assessment?
Nutrition Assessment

Q.1 Does the patient need to be fed?
✓ Is the patient malnourished or at nutritional risk?

Q.2 If yes, when should feeding begin?
✓ Weight loss
✓ Degree of stress
✓ Duration of NPO

Q.3 If now, how should patient be fed?
✓ EN (p.o., Gastric, Jejunal) vs PN (PPN, CPN)
✓ Nutritional design
Presentation of Case 1

Enteral Nutrition
**Case 1**

**Hx:** 67 yo WM admitted to hospital with failure to thrive. Losing wt over 2-years. Brought to ED by his son because of acute right sided weakness and facial droop.

**PMH:** Previously overweight with hyperglycemia. Mild COPD; past tobacco use. HTN, GERD, history of seizures.

Wt 65 kg 2-yr ago (BMI 21.2), 58 kg 1-yr ago (BMI 18.9).

**SocHx:** Retired university professor. Formerly active socially. Wife died 2-yrs ago from breast cancer. Lives alone, drinks alcohol, and rarely leaves home. One son, an attorney.


Normal thyroid, heart, lungs, abdominal, extremity exam.
Meds: omeprazole 20 mg 1/d, phenytoin 300 mg 1/d, aspirin 81 mg 1/d, HCTZ 25 mg 1/d, atenolol 50 mg 1/d. No OTC vitamins or supplements.

Lab: hgb 11.7 g/dL (nl 12.0-15.5), mcv 98 (81.6-98.3), wbc 8.7 x10(9)/L (3.5-10.5), Na 145 mmol/L (135-145), K 3.7 mmol/L (3.6-5.2), P 2.8 mg/dL (2.5-4.5), HCO3 28 mmol/L (22-29), Cr 1.2 mg/dL (0.6-1.1), Ca 10.1 mg/dl (8.9-10.1), Mg 1.8 mg/dL (1.7-2.3), BG 88 mg/dL (70-100), AST 61 U/L (8-43), alkaline phosphatase 121 U/L (37-98), total bilirubin 2.4 mg/dL (0.1-1.1), albumin 3.9 g/dL (3.5-5.0).

Tests: MRI head: MCA stroke, ischemic vascular changes.

ECG: NSR. CXR: hyperinflation, right basilar fibrosis.

Disposition: Admitted to medical service for observation. IV fluids D5W-half normal saline at 125 cc/hour.
Case 1 – cont.

**Disposition:** Medical service placed a NG-FT and began TF 2 cans tid, standard 1.0 cal/cc. Peripheral IV fluid D5W-half normal saline continued at 125 cc/hr. Tylenol ordered prn pain.

**Labs (day 2):** Cr 1.0 (0.6-1.1), Na 140 (135-145), K 3.1 (3.6-5.2), P 1.5 (2.5-4.5), Ca 8.7 mg/dl (8.9-10.1), Mg 1.3 mg/dL (1.7-2.3), BG 164 (70-100), albumin 3.0 g/dL (3.5-5.0).

**Tests:** ECG prolonged QT-interval. Low serum Dilantin. CXR now shows RLL infiltrate.

**Questions:**
1. What happened?
2. How should the electrolytes and minerals be managed?
3. Should the nutrition be changed?
Pathogenesis of Refeeding

Starvation/Malnutrition $\rightarrow$ gluconeogenesis $\rightarrow$ fat / protein catabolism

$\downarrow$

Skeletal muscle and visceral organ protein loss

$\downarrow$

Water, vitamin and mineral depletion

$\downarrow$

Refeeding

$\downarrow$

Shift to CHO as energy source, $\uparrow$ insulin secretion

$\downarrow$

$\uparrow$ cellular uptake of glucose, P, K, Mg
Refeeding Syndrome
Major Clinical Features

Labs:
- Hypophosphatemia (severe ≤1 mg/dL)
- Hypokalemia (severe ≤2 meq/L)
- Hypomagnesemia (severe ≤1 mg/dL)

Organs:
- Cardiac – arrhythmia, CHF, edema
- Pulmonary – ventilatory failure, effusions
- Neurologic – confusion, paresthesias, weakness/paresis, seizures
Refeeding Syndrome
Recognize the patient at risk

• Large weight loss in any patient
  • Chronic underweight malnutrition
    – BMI <18, anorexia nervosa, prolonged fast
    – Wasting (ALS, HIV, etc.) or cachexia (cancer, CHF, etc.), chronic alcoholism
  • Chronic malabsorption
    – Sprue, CF, pancreatitis, bariatric surgery, etc.

• Present electrolyte / mineral abnormalities
  • Before and/or after refeeding
Avoiding the Refeeding Syndrome

Recommendations

• Recognize, assess, treat the patient at risk
  • Correct electrolyte and mineral abnormalities before initiating nutrition
  • Provide thiamine and vitamins as needed
• Judicious fluid delivery
• Increase caloric delivery gradually
• Monitor daily
  • Fluid balance, weight, electrolytes, minerals
Metabolic Milieu of Refeeding

- **Hyperglycemia**
  - Osmotic diuresis
  - Increased risk of infection
  - Hepatic steatosis

- **Hyperinsulinemia**
  - Impairs Na\(^+\) and water excretion
  - Decreases serum K\(^+\), Phos, and Mg\(^{++}\)

- **Increased minute ventilation**
  - Increased O\(_2\) consumption and CO\(_2\) production

- **Refeeding syndrome risk in malnourished**
Case 1 – cont.

**Disposition:** Primary service placed a nasogastric feeding tube on the hospital ward and is providing tube feeding as 2 cans tid, standard 1.0 cal/cc TF formula. Gastric residuals 80-180 cc. IV fluid continued. Tylenol prn pain.

WM – 67 yrs, 175 cm, 45 kg (BMI 14.7)

**Questions:**

4. What are the nutrient needs?
   - For calories?
   - For protein?
Management of Nutrition Support

- **Indication**

- **Nutrition formula**
  - Calories
  - Nutrients (Protein, Lipid, Carbohydrate)
  - Fluid volume

- **Route**
  - EN vs PN

- **Metabolic and acid-base issues**

- **Drug nutrient interactions**
Calorie Energy Requirements

Harris-Benedict (HB) equation

Women  \[655 + 9.6 \text{ kg} + 1.9 \text{ cm} - 4.7 \text{ yrs}\]

Men  \[66.5 + 13.8 \text{ kg} + 5 \text{ cm} - 6.8 \text{ yrs}\]

Indirect calorimetry (IC)

\[EE (\text{kcal}) = [(3.8) (V\text{O}_2) + (1.2) (V\text{CO}_2) \times 1.44]\]
Energy Needs in Critically ill
Measured vs Estimated*

• 55 ICU patients within 48-hrs major surgery
  19 F, 36 M
  Age: 60 ± 12 yr
  Wt: 75 ± 16 kg (BMI 26 ± 4)
  Stress: APACHE II 17 ± 3.5

• **Measurement** (REE): 1,563 ± 403 kcal/day

• **Estimate** (HB): 1,535 ± 296 kcal/day

(*p < 0.0001; r = 0.87)
Miles JM. *Mayo Clin Proc* 2006;81:809
# Nutrition Requirement Guidelines

<table>
<thead>
<tr>
<th></th>
<th>Ward</th>
<th>ICU</th>
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<tbody>
<tr>
<td>Calories⁠¹</td>
<td>HB + 20%</td>
<td>Basal HB</td>
</tr>
<tr>
<td>Protein</td>
<td>1.0 g/kg</td>
<td>1.5 g/kg</td>
</tr>
<tr>
<td>Lipid</td>
<td>20% to 30% of total calories</td>
<td></td>
</tr>
<tr>
<td>Fluid⁡²</td>
<td>30 mL/kg (1 cc/calorie)</td>
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</tr>
</tbody>
</table>

⁠¹IC in severely stressed, ventilator-dependent with weaning difficulty or requiring HPN. ⁡²Assuming normal renal & cardio-pulmonary function.
<table>
<thead>
<tr>
<th>Formula</th>
<th>Kcal/ml (kcal/can)</th>
<th>Protein gm/L (gm/can)</th>
<th>Protein Source</th>
<th>Fat gm/L</th>
<th>Fat Nutrient Source and % MCT/L</th>
<th>Carbohydrates gm/L</th>
<th>Carbohydrate Nutrient Source</th>
<th>Osmolality mOsm/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osmolite 1 Cal (Abbott)</td>
<td>1.06 (250)</td>
<td>44 (10.5)</td>
<td>sodium and calcium caseinates, soy protein isolate</td>
<td>35</td>
<td>canola oil, corn oil, 20% MCT oil, soy lecithin</td>
<td>144</td>
<td>corn maltodextrin, corn syrup solids</td>
<td>300</td>
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<tr>
<td>Jevity 1 Cal (Abbott)</td>
<td>1.06 (250)</td>
<td>44 (10.4)</td>
<td>sodium and calcium caseinates, soy protein isolate</td>
<td>35</td>
<td>canola oil, corn oil, 19% MCT oil, soy lecithin</td>
<td>155</td>
<td>corn maltodextrin, corn syrup solids</td>
<td>300</td>
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<tr>
<td>Promote (Abbott)</td>
<td>1 (237)</td>
<td>62.5 (14.8)</td>
<td>sodium caseinates, soy protein isolate</td>
<td>26</td>
<td>soy oil, 19% MCT oil, safflower oil, soy lecithin</td>
<td>130</td>
<td>corn maltodextrin, sugar (sucrose)</td>
<td>340</td>
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<td>Promote with fiber (Abbott)</td>
<td>1 (237)</td>
<td>62.5 (14.8)</td>
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<td>corn maltodextrin, sugar (sucrose)</td>
<td>380</td>
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<td>62.7 (14.9)</td>
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<td>49</td>
<td>safflower oil, canola oil, 20% MCT oil, soy lecithin</td>
<td>204</td>
<td>corn maltodextrin</td>
<td>525</td>
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<tr>
<td>Jevity 1.5 (Abbott)</td>
<td>1.5 (355)</td>
<td>63.8 (15.1)</td>
<td>sodium and calcium caseinates, soy protein isolate</td>
<td>50</td>
<td>canola oil, corn oil, 19% MCT oil, soy lecithin</td>
<td>216</td>
<td>corn maltodextrin, corn syrup solids, fructooligosaccharides</td>
<td>525</td>
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<tr>
<td>Two Cal HN (Abbott)</td>
<td>2.0 (475)</td>
<td>83.5 (19.9)</td>
<td>sodium and calcium caseinates</td>
<td>91</td>
<td>safflower oil, 19% MCT oil, canola oil, soy lecithin</td>
<td>219</td>
<td>corn syrup solids, corn maltodextrin, sugar (sucrose), fructooligosaccharides</td>
<td>725</td>
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</table>
Gastric Tube Feeds (vs Jejunal)

Advantages

- Gravity feeding results in a more physiologic hormone profile
- Infusion pump is not required
- Data for absorption of medications infused into the jejunum is limited

Disadvantages

- Potential aspiration risk in ICU patients
- Residual volume for aspiration risk not universally agreed upon
Tube Feeds and Medications

Mechanism of Drug Absorption

• Occurs primarily in SB by passive diffusion
  • Some drugs are absorbed by active transport
• Food can either ↓, ↑, delay or have ns effect on drug absorption
Tube Feeds & Medication Absorption

**Decreased absorption**

- Nitrofurantoin
- Grisiofulvin - fatty meal
- Saquinavir - fatty meal
- Levodopa - competition with proteins for absorption/transport sites
- Phenytoin - binding to caseinates / calcium
- Ciprofloxacin - decreased drug stability
Median % Drug Lost in Ensure Tube Feeds Compared to Water

- Ciprofloxacin: 82.5%
- Ofloxacin: 45.8%
- Levofloxacin: 61.3%
TF Drug Recommendations

- Liquid drug forms preferred
  - If hypertonic-viscous, dilute with 15-60mL water
- **Do not crush** enteric-coated/extended-release med
- Mix tablets or gelatin capsules with 10-15mL water
  - Continuous TF stopped and FT flushed with 30 mL water before drug administration
  - Administer each dose separately and flush with 5 mL water between doses
  - Flush FT with 30 mL water after last drug dose
- **Do not add drugs to container or formula**
  - Unless physical, chemical, therapeutic outcome known
TF and Pharmaceutical Issues:

**DO NOT CRUSH**

- **Extended Release Pharmacokinetics**
  - Releases drug over time
    - Allows reduction in dosing frequency

- **Examples:**
  - Theo-Dur® Tablet, Slo-Phyllin Gyrocap®
  - Slow-K®, Klotrix® (*Wax matrix KCl*)
  - Procardia XL® Tablet
  - Trental® Tablet
TF and Pharmaceutical Issues:

**DO NOT CRUSH**

- **Enteric Coated Medications**
  - Prevents drug inactivation by stomach acids

- **Examples:**
  - Bisacodyl (Dulcolax®)
  - Pancrelipase (Pancrease®)
  - Proton Pump Inhibitors
    - (Prilosec®,Prevacid®, Aciphex®, Protonix®, Nexium®)
TF and Proton Pump Inhibitors

Acid-labile medications

- Only available as enteric coated dosage forms
  - Capsules, of enteric coated pellets – Prilosec,Prevacid, Nexium
  - Tablets, enteric coated – Protonix, Aciphex
- Methods of feeding tube administration:
  - Flushing of intact granules with water - may clog FT
  - Preparation of NaHCO₃-based suspension
    - Degrades enteric coating, but stabilizes drug
    - Omeprazole powder for oral suspension – Zegerid
Proton Pump Inhibitors

Enteric coated pellets from PPI capsules
Case 1 – cont.

Disposition: NG tube feeding 2 cans t.i.d., standard 1.0 cal/cc formula. Omeprazole and phenytoin administered via FT. Tylenol liquid q6h for pain. Diarrhea now present.

Video swallow: Positive for aspiration (NPO advised).

Questions:
5. What could be the cause of the diarrhea?
6. Should the TF program be changed?
   Should the formula be changed?
   Should fiber be added?
   Should probiotics be used?
Tube Feeds and Medications

Sorbitol

- Sorbitol used as sweetener and “alcohol” solvent
  - Amount in liquid medication not regulated or labeled
- Effect of chronic doses not well known
  - >10-15 g/day associated with bloating, cramping, or osmotic laxative / diarrhea effect

Examples

- Acetaminophen, Theophylline

Note: generics may contain differing sorbitol amounts
Tube Feeds and Medications

Osmotic load

- **Effect on SB**
  - May cause “dumping syndrome”
  - Univ. of PA study: osmolality of oral liquid meds
    - 6 of 58 (10%) < 1000 mOsm/kg
    - 52 of 58 (90%) 1,050 to 10,950 mOsm/kg

- **Examples:**
  - Acetaminophen Elixir 5400 mOsm/kg
  - Metoclopramide Syrup 8350 mOsm/kg
  - K-Cl Liquid 4350 mOsm/kg
<table>
<thead>
<tr>
<th>Formula</th>
<th>Koal/mL</th>
<th>Protein gm/L</th>
<th>Protein Source</th>
<th>Fat gm/L</th>
<th>Fat Nutrient Source and % MCT/L</th>
<th>CHO gm/L</th>
<th>CHO Nutrient Source</th>
<th>Osmolality mOsm/kg</th>
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<tr>
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<tr>
<td>Replete with Fiber (Nestle)</td>
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<td>64</td>
<td>soy protein isolate, sodium and calcium caseinate</td>
<td>34</td>
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<td>corn syrup, maltodextrin, dextrose</td>
<td>330</td>
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<td>60</td>
<td>canola oil, 20% MCT oil, soy lecithin</td>
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<td>corn syrup, maltodextrin, dextrose</td>
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<tr>
<td>IsoSource 1.5 (Nestle)</td>
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<td>soy protein isolate, sodium and calcium caseinate</td>
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<td>soy protein isolate, sodium and calcium caseinate</td>
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<td>216</td>
<td>corn syrup, maltodextrin</td>
<td>780</td>
</tr>
</tbody>
</table>
Presentation of Case 2

Parenteral Nutrition
Case 2

**Hx:** 40 yo WF with very long limb RYGB 6 mo ago for super obesity. Has had N, V, and loose stools 2-3/d since surgery. Hypogastric pain for 3 wks. Admitted to ICU.

**PMH:** Pre-RYGB therapy for T2DM (insulin), HTN (lisinopril), OSA (CPAP). Remote DVT.

**SocHx:** Never smoked, no alcohol, married, court reporter.

**Exam:** 177 cm, 142 kg (preop 181 kg), BMI 45. BP supine 110/70 (90/50 sitting), HR 90 (120 sitting) RR 24 (90% O2 saturation - room air). Appears ill, confused, disoriented. Nystagmus. Dry, smooth tongue. Dry, lax skin. Decreased hand grip, facial wasting. Abdominal scars with pannus, tender and distended mid-section. Legs edematous, venous stasis. Decreased vibratory sensation. Normal lungs, heart, thyroid, lymph exam.
Case 2

**Meds:** multivitamin + mineral 1/d; vitamin D3 1000 IU/d; Tums 500 mg bid; insulin 70/30 bid (10/15 units am/pm). Stopped oral Rx/OTC meds 6 wks ago because of N,V. Stopped insulin 3 wks ago.

**Lab:** hgb 10.7 g/dL (nl 12.0-15.5), mcv 101 (81.6-98.3), wbc 18 x10⁹/L (3.5-10.5), Na 155 mmol/L (135-145), K 3.2 mmol/L (3.6-5.2), P 5.5 mg/dL (2.5-4.5), HCO₃ 18 mmol/L (22-29), Cr 1.1 mg/dL (0.6-1.1), BUN 50 mg/dL (6-21), BG 199 mg/dL (70-100), A1c 6.8% (4-6%), AST 31 U/L (8-43), alkaline phosphatase 122 U/L (37-98), albumin 2.3 g/dL (3.5-5.0).

**Tests:** ECG: sinus tachycardia

CXR: RLL infiltrate

CT-chest: RLL infiltrate, negative for PE

CT-abdom: fluid collection at GJ anastomosis, ascites
Case 2 – cont.

Disposition: 40 yr WF, ICU and surgical team request immediate (day 1) parenteral nutrition (PN) support. Patient is NPO and surgery planned in 1-wk.

Labs: Cr 1.5 (0.6-1.1), BUN 65 (6-21), Na 142 (135-145), K 5.1 (3.6-5.2), P 4.5 (2.5-4.5), BG 204 (70-100)

177 cm, 142 kg (preop 181 kg; 22% loss), BMI 45.

Questions:
1. What is your nutrition assessment?
   Should this patient be fed?
   Is so, when? If so, how?
2. What other tests are needed, if any?
Case 2 – cont.

**Labs:** Cr 1.5 (0.6-1.1), BUN 65 (6-21), Na 142 (135-145), K 5.1 (3.6-5.2), P 4.5 (2.5-4.5), BG 204 (70-100)

177 cm, 142 kg (preop 181 kg; 22% loss), BMI 45.

**Questions:**

4. How would you design the nutrition program?
   a. Route, EN (G/J) or PN (CPN/PPN)
   b. Calories, for the patient with obesity vs non-obese
   c. Protein – in health, CKD, dialysis, CRRT
   d. Lipid – in CPN vs PPN, and rate
   e. Dextrose – and insulin administration
   f. Volume
   g. CPN vs PPN additives – electrolytes, minerals, MV
Case 2 – cont.

Disposition: 40 yo WF, 177 cm, weight up 10 kg, edematous. CPN unchanged.
CXR worsening RLL infiltrate – steroids initiated.
CRRT started for ARF and to pull fluid.
BG range now 268-318 mg/dL.
Cultures pending.

Questions:
6. What are the causes of hyperglycemia in hospitalized pts?
   a. Is BG treatment the same in pts with and w/o T2DM?
   b. What treatment would you use?
   c. What is the goal BG in hospitalized pts?
Calorie Sources From CRRT

- **CRRT** – continuous renal replacement therapy is widely used in acute kidney injury
- Theoretical source of calories from CRRT fluids
  - Dextrose
  - Citrate
  - Lactate
- CVVH / CVVDHF + lactate-based replacement fluids + citrate anticoagulation (ACD) have been suggested to supply ~1400 kcal/day

Calorie Sources From CRRT

**ACD Inlet**
- Citrate 2.2%
- Dextrose 2.45%

**Pre-filter Fluids**
- Dextrose 0.11%
- Lactate 3 mmol/L

**Post-filter Fluids**
- Dextrose 0.11%
- Lactate 3 mmol/L

Venous access → Blood pump → Dialyzer → Effluent → Venous return

**Pre-filter Sample**

**Post-filter Sample**

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**Design**
- Single-center, prospective, observational study

**Timeframe**
- April 2014 – July 2014

**Population**
- 10 adult patients on CVVH for ≥ 12 hours

**Study Aim**
- Quantify delivery of citrate and glucose from CVVH fluids

**Study Samples**
- 4 samples, 10 minutes apart, taken from pre-filter and post-filter ports on 2 consecutive days
<table>
<thead>
<tr>
<th>Variable</th>
<th>CVVH (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>61±4</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>5 (50%)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>28±2</td>
</tr>
<tr>
<td>Comorbidities, n (%)</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>5 (50%)</td>
</tr>
<tr>
<td>Chronic liver dysfunction</td>
<td>2 (20%)</td>
</tr>
<tr>
<td>Surgical diagnosis, n (%)</td>
<td>7 (70%)</td>
</tr>
<tr>
<td>CVVH characteristics</td>
<td></td>
</tr>
<tr>
<td>Blood flow rate (mL/min)</td>
<td>200</td>
</tr>
<tr>
<td>ACD rate (mL/min)</td>
<td>5</td>
</tr>
<tr>
<td>Estimated BEE (HB equation, kcal/d)</td>
<td>1543±81</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Macronutrient</th>
<th>Delivery (mg/min)</th>
<th>Energy Gain (kcal/d)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>55±5</td>
<td>299±27</td>
</tr>
<tr>
<td>Citrate</td>
<td>57±3</td>
<td>200±8</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>502±33</td>
</tr>
</tbody>
</table>
Factors Affecting Blood Glucose

• Nutrition program
  • Excess calories (EN-PN, dextrose-containing crystalloid, propofol, CRRT, Peritoneal Dialysis)

• Response to illness/infection
  • Counter-regulatory hormones and cytokines

• Medications
  • Corticosteroids, sympathomimetics, cyclosporine

• Organ dysfunction
  • Hepatic and peripheral insulin resistance
Hyperglycemia and Infection

- Central catheter-related infections were 5X more common in diabetic patients on CPN
  - Hyperglycemia within 3 days before isolation of Candida was the most common risk factor for infection
- Risk reduction in septic complications during TF vs CPN
  - Glucose ave. 130 mg/dL vs 230 mg/dL

References:
Management of BG During PN

- Limit dextrose to 200 g (PN and crystalloid)
- Add insulin to PN
  - Begin with 0.1 units of Regular insulin/g of dextrose (eg, 10 units/100 g)
- Adhere to insulin algorithm (SQ or IV)
- Monitor
  - Frequent glucose measurements
  - Follow wt and I/O’s, electrolytes and minerals
- Cause of unexplained change in glucose levels should be determined
Management of BG During PN

Hospital BG goal 140-180 mg/dL

- If glucose < 180 mg/dL
  - Dextrose load (and insulin) may be increased

- If glucose ≥ 180 mg/dL
  - Increase insulin in PN each day by 0.05 units increment to goal of 0.2 units/g

- Consider IV insulin infusion if BG remains elevated
Management of BG During PN
Short-Acting SQ Insulin Algorithm

<table>
<thead>
<tr>
<th>Plasma glucose (mg/dL)</th>
<th>SQ regular insulin dose (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 - 200</td>
<td>2 - 4</td>
</tr>
<tr>
<td>200 - 250</td>
<td>4 - 6</td>
</tr>
<tr>
<td>251 - 300</td>
<td>6 - 8</td>
</tr>
<tr>
<td>301 - 350</td>
<td>8 - 10</td>
</tr>
<tr>
<td>351 - 400</td>
<td>10 - 12</td>
</tr>
</tbody>
</table>

**Note:** Short acting SQ insulin should not be given more than every 2-hours.
### Management of BG During PN

**IV Insulin Infusion**

<table>
<thead>
<tr>
<th>Glucose (mg/dL)</th>
<th>Insulin infusion rate (units/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;400</td>
<td>8</td>
</tr>
<tr>
<td>351-400</td>
<td>6</td>
</tr>
<tr>
<td>301-350</td>
<td>4</td>
</tr>
<tr>
<td>250-300</td>
<td>3</td>
</tr>
<tr>
<td>200-249</td>
<td>2.5</td>
</tr>
<tr>
<td>150-199</td>
<td>2</td>
</tr>
<tr>
<td>120-149</td>
<td>1.5</td>
</tr>
<tr>
<td>100-119</td>
<td>1</td>
</tr>
<tr>
<td>70-99</td>
<td>0</td>
</tr>
<tr>
<td>&lt;70</td>
<td>0</td>
</tr>
</tbody>
</table>
CONCLUSIONS

• Hormonal and cytokine milieu of illness/inflammation leads to protein calorie malnutrition (PCM)

• During illness, hypoalbuminemia is best viewed as a marker of stress

• Overfeeding should be avoided

• Goals of short-term nutrition are to support protein synthesis and enhance immune function
Thank You

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