Promoting the Safe and Appropriate Use of Parenteral Nutrition: Overview of the New Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient

Gordon S. Sacks, Pharm.D., BCNSP, FCCP

Professor and Department Head
Pharmacy Practice
Harrison School of Pharmacy
Auburn University
Disclosures

• Gordon Sacks, Pharm.D., reports that he has been a consultant for Fresenius Kabi and is a member of both the A.S.P.E.N. and A.S.P.E.N. Rhoads Research Foundation Board of Directors.
Learning Objectives

• Review important recommendations in the new guidelines for the provision and assessment of nutrition support therapy in critically ill adult patients.
• Explain strategies for patient assessment and management that will minimize complications and lead to improved patient outcomes.
• Review the mechanical, gastrointestinal, and infectious risks associated with parenteral nutrition (PN), including ways to prevent them.
• Describe how to best implement the guidelines into practice.
Methodology

- Updated and expanded 2009 ASPEN / SCCM guidelines
- Database of randomized controlled trials (RCTs) assembled in partnership with Canadian Clinical Guidelines group
- Included published literature through December 31, 2013
- Target patient population: Adult (> 18 years) critically ill patients with ≥ 2 days medical or surgical intensive care unit (ICU) length of stay (LOS)
- New subsets of patients addressed includes organ failure, acute pancreatitis, surgical subsets, sepsis, postoperative major surgery, obese
Methodology

• Multidisciplinary clinicians jointly convened by both societies to conduct update
• RCTs were preferred source material, but nonrandomized trials, prospective observational studies and retrospective case studies were used to support responses
• GRADE criteria used to evaluate body of evidence for a given intervention and outcome
• Every committee member was polled anonymously for his/her agreement with each recommendation
• Consensus was arbitrarily set at 70% agreement
**Strength of Evidence**

- **High:** Randomized trial
  - Further research unlikely to change confidence of estimate of effect
- **Moderate**
  - Further research likely to impact
- **Low:** Observation trial (Cohort, Case series, Case study)
  - Further research very likely to have an important effect on confidence
- **Very low:** expert opinion
  - Any estimate of effect is uncertain

**Criteria to Increase or Decrease Grade**

- **Decrease grade if:**
  - Serious limitation to study quality
  - Important inconsistency
  - Uncertainty about directness
  - Imprecise or sparse data
  - High probability of bias
- **Increase grade if:**
  - Strong evidence of association
  - Evidence of a dose-response gradient
  - Plausible confounders accounted for

*BMJ 2004;328(7454):1490-1494*
Overview of Process

Entire process occurred over a 4-year timeline
Published page count is 52 pages
480 reference citations
> 800 studies reviewed
Guideline Sections

A. Nutrition Assessment
B. Initiation of Enteral Nutrition (EN)
C. Dosing of EN
D. Monitoring Tolerance and Adequacy of EN
E. Selection of Appropriate EN Formulation
F. Adjunctive Therapy (fiber, probiotics, glutamine)
G. When to Use Parenteral Nutrition (PN)
H. When Indicated, Maximize Efficacy of PN
Guideline Sections

I. Pulmonary Failure
J. Renal Failure
K. Hepatic Failure
L. Acute Pancreatitis
M. Surgical Subsets (Trauma, Traumatic Brain Injury (TBI), Open abdomen, Burns)
N. Sepsis
O. Postoperative Major Surgery
P. Chronically Critically Ill
Q. Obesity in Critical Illness
R. Nutrition Therapy End-of-Life
Don’t Shoot the Messenger of these Guidelines!
Case Scenario #1

• 77 yo woman presented to the emergency department (ED) with 2-day history of burning with urination and sharp lower abdominal pain that worsened over time
• Past medical history (PMH) significant for hypothyroidism, hyperlipidemia, iron deficiency anemia, and cervical cancer treated with radiation therapy 20 year prior; since that time has had multiple urinary tract infections (UTIs)
• Tried to relieve dysuria with pyridium, but no improvement
• Home medications: simvastatin, levothyroxine, iron, weekly vitamin D for osteoporosis
• Allergy: sulfa
• Denies tobacco; drinks alcohol < 1x/month
Case Scenario #1

- Anthropometrics: Height 66 in; weight 114 lb (52 kg);
  - Body mass index (BMI) 18.5 kg/m²; decreased appetite x 1 week prior to admission (PTA)
- Physical exam (PE): remarkable for abdominal tenderness over pubis and labia majora extending into perineum; induration and edema of the vulva; no flank tenderness, drainage, edema
- Baseline vital signs: Temp 36.8°C, heart rate (HR) 122 (sinus tachycardia), blood pressure (BP) 110/50 mm Hg, respiratory rate (RR) 20, oxygen saturation 97-99%
- Labs: White blood cells (WBC) 24.2 x 10³/μL, hemoglobin/hematocrit 7.9/25.5, platelets 715/μL
- Urinalysis: hazy, orange color
- Specific gravity (SG) 1.015, WBC > 182 x 10³ μL
- Positive for bacteria in clumps

NCP 2016;31:334-341
Case Scenario #1

• At presentation, positive for 2/4 systemic inflammatory response syndrome (SIRS) criteria with tachycardia and leukocytosis possibly related to urosepsis or soft tissue infection of vulva
• Admitted to floor, received ceftriaxone 1 gram/day with fluid resuscitation, blood/urine cultures, and Foley catheter
• Evidence of acute kidney injury (AKI) with elevated creatinine = 1.5 mg/dL; also prerenal azotemia with mild hyperkalemia
• Additional diagnostics: CT pelvis consistent with necrotizing soft tissue infection requiring surgery
• Procedure: wound debridement perineum, labia, lower abdominal wall
• Transferred to ICU with open abdomen, mechanical ventilation (MV)
Case Scenario #1

- Medications included propofol, fentanyl, norepinephrine to keep mean arterial pressure (MAP) > 60 mm Hg
- Vancomycin and metronidazole IV for positive urine culture
- Nothing by mouth (NPO), nasogastric tube (NGT) in place
- Does this patient need nutrition support?
- If so, should you start PN or EN?
Audience Response Question

Which of the following is the MOST appropriate next step for this patient?

A. No action is needed since this patient is at low nutritional risk
B. Enteral nutrition (EN) at full goal rate should be initiated as soon as possible
C. EN trophic feeds with parenteral nutrition (PN) should be initiated due to vasopressor requirements
D. Exclusive PN without EN should be initiated as soon as possible
Case Scenario #1

• Application of the Guidelines

• A1. “Based on expert consensus, we suggest a determination of nutrition risk (e.g., Nutritional Risk Screening (NRS) 2002, NUTRIC score) be performed on all patients admitted to the ICU for whom volitional intake is anticipated to be insufficient. High nutrition risk identifies those patients most likely to benefit from early EN therapy”
### Nutrition Risk Screening (NRS 2002)

<table>
<thead>
<tr>
<th>Nutrition status impairment</th>
<th>Severity of disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score 0 Absent</td>
<td>Normal nutritional status</td>
</tr>
<tr>
<td>Score 1 Mild</td>
<td>Weight loss &gt; 5% in 3 months OR Food intake &lt; 50-75% of normal</td>
</tr>
<tr>
<td>Score 2 Moderate</td>
<td>Weight loss &gt; 5% in 2 months OR BMI 18.5-20.5 + impaired general condition OR Food intake 25-50% of normal</td>
</tr>
<tr>
<td>Score 3 Severe</td>
<td>Weight loss &gt; 5% in 1 month OR BMI &lt; 18.5 + impaired general condition OR Food intake 0-25% of normal</td>
</tr>
</tbody>
</table>

**Factors used to determine score** - A score of \( \geq 3 \) identifies a patient for whom specialized nutrition therapy (EN or PN) should be considered. A score of \( \geq 5 \) identifies a patient at high nutritional risk.
Case Scenario #1

• G2. Based upon expert consensus, in the patient determined to be at high nutrition risk (e.g., NRS 2002 score ≥ 5 or NUTRIC ≥ 6, with > 5 if no IL-6 value) or severely undernourished, when EN is not feasible, we suggest initiating exclusive PN as soon as possible following ICU admission.
  – Nutrition Care Plan: Determined to be at high risk due to severity of illness, predicted NPO status due to numerous surgical follow-up procedures, low BMI, poor appetite.
  – NRS 2002 = 5
  – EN trophic feeds + PN initiated due to requirement of vasopressor agents
  – Regimen supported by Doig trial (CALORIES)
    • RCT of 1372 patients found that early PN (within 48 hr) with relative contraindications to early EN → significantly fewer days of MV, no difference in 60-day mortality, ICU LOS, hospital LOS

Case Scenario #1

- H4. Based upon expert consensus, use of standardized commercially available PN vs. compounded PN admixtures in ICU patienta has no advantage in terms of clinical outcomes.
  - Nutrition Care Plan: Initially started commercially available PN. Around day 4, patient switched to customized compounded PN formulation due to high protein requirements and continuous adjustment of electrolytes.
- H2. We suggest that hypocaloric PN dosing (≤ 20 kcal/kg/day or 80% estimated energy needs) with adequate protein be considered in appropriate (high-risk or severely undernourished) patients requiring PN, initially over the first week ICU hospitalizations.
  - Patient received ≈73-85% of caloric goal (1108 vs. 1307 kcal/day using predicted equation) during first week of PN.
  - Propofol was not used for sedation, but rather dexmedetomidine and fentanyl for pain.

*References:*

NCP 2016;31:334-341; JPEN 2016;40:159-211.
Beware of Presenter Bias for this Guideline!

- H3a. Suggest withholding or limiting soybean oil-based (SO) intravenous fat emulsion (IVFE) during first week following initiation of PN in critically ill patients to a maximum of 100 g/week (often divided into 2 doses/week) if concern for essential fatty acid deficiency (EFAD).
  - Committee reached only 64% agreement (9 for/5 against) to “withhold or limit” SO-based IVFE to 100 g/week as opposed to simply “withhold” for first week
  - Recommendation to entirely “withhold” SO-based IVFE for 1-week based upon old and flawed study in which results have never been replicated.
  - Battistella study was conducted in trauma patients randomized to IVFE-free PN vs. SO-based IVFE PN for first 10 days of hospitalization
    - IVFE-free PN group was hypocaloric regimen (21 vs. 28 kcal/kg/day)
    - Caloric goals were based on NPC (non-protein calories)
    - IVFE infusion rates < 12 hour associated with immune dysfunction

Case Scenario #1

• H3b. Alternative IVFE may provide outcome benefit over SO-based IVFE, but we cannot make a recommendation at this time due to the lack of availability of these products in the United States (US).

• When these alternative IVFE (Medium chain triglycerides [MCT], Olive oil [OO], Fish oil [FO], soybean oil [SO]) become available in the United States, based upon expert opinion, we suggest their use be considered in the critically ill patient who is an appropriate candidate for PN.

• H5. We recommend a targeted blood glucose range of 140 to 180 mg/dL for the general ICU population; ranges for specific patient populations may differ (after cardiovascular (CV) surgery, TBI) and are not covered in these guidelines.
Alternative IVFE Products

- Olive-oil (OO) based IVFE was approved in the US in October 2013

Fig. 3 Overall effect on ventilation days of ω-6-reducing strategy vs. LCT. LCT long-chain triglycerides, 95% CI 95% confidence intervals, SD standard deviation

Alternative IVFE Products

- Soybean oil, MCT, Olive Oil, Fish oil (SMOF) based IVFE was approved in July 2016
  - No significant differences in mortality, days of MV
  - Significantly reduced infections
  - No significant differences in days of MV

Infections - RR 0.64; 95% CI 0.44 to 0.94; P=0.02
Case Scenario #1

- Efforts were made to initiate EN within 24 hours of ICU admission while she was also on PN.
- Due to gastric feeding intolerance and delayed tolerance of small bowel feeding, as well as recurring periods of NPO status for follow-up surgeries, PN almost exclusively met her early nutrition needs.
- EN considerations focused on her need for high protein due to high exudate drainage output, tissue repair, and wound healing.
- ICU day 4, SB access was established by the surgeon when she underwent surgical washout procedure.
- ICU day 9, the EN formulation had reached >60% of goal rate and PN discontinued.

Photo credit, Steve McClave, MD. Used with permission.
Case Scenario #1

Guideline Application

• H7. Based on expert consensus, we suggest that as EN tolerance improves, the amount of PN energy should be reduced and finally discontinued when the patient is receiving >60% target energy requirements from EN.

• J1. Based upon expert consensus, we suggest that ICU patients with AKI should be placed on standard EN formulations, and standard ICU recommendations for protein (1.2-2 g/kg actual body weight/day) and energy (25-30 kcal/kg/day) provision should be followed. If significant electrolyte abnormalities develop, a specialty formulation designed for renal failure may be considered.

• M3b. Based upon expert consensus, we suggest providing an additional 15 – 30 g protein/L exudate lost for open abdomen patients.
Case Scenario #1

- Patient returned to the operating room (OR) on numerous occasions for debridement and washout procedures.
- She experienced complications of an extension of necrotizing fasciitis to the rectum requiring colostomy and sustained a bladder injury necessitating a cystectomy with an ileostomy.
- PN therapy was reinitiated while these issues were managed over the course of 10 days.
- When EN was restarted, an immune-modulating EN formulation was chosen.
- Patient continued to receive high-nitrogen, immune-modulating EN formulation until she was no longer returning to OR on a regular basis and tolerating an oral well.
Case Scenario #1

Guideline application

- O2. We suggest EN be provided, when feasible, in the postoperative period within 24 hours of surgery as it results in better outcomes than use of PN or standard therapy (i.e., IV fluids, no EN or PN, advancement to oral diet as tolerated).
- O3. We suggest routine use of immune-modulating EN formulations (arginine + fish oils) in the surgical ICU for the postoperative patient who requires EN.
- O4. We suggest EN for many patients in difficult situations such as prolonged ileus, open abdomen, intestinal anastomosis, and need of vasopressor agents for hemodynamic support.

JPEN 2016;40:159-211.
Application of Guidelines – Case Scenario #2

- 49 yo male presents to ED with severe abdominal pain, anorexia, nausea and vomiting (N/V)
- Unable to tolerate solid food for 2 days
- PMH: poorly controlled type 2 diabetes mellitus (DM II), obese, hypertriglyceridemia, negative history of pancreatitis or alcoholism
- Medications: fenofibrate 80mg/d, glipizide 5 mg/d, insulin glargine 60 units every night
- Anthropometrics: Height 68 in., weight 250 lb. (113.6kg), BMI 38 kg/m², gained 5 lbs. in previous 1 month
- ED labs: Blood glucose (BG) – 425 mg/dL, tryglycerides (TG) – 4420 mg/dL, lipase – 11,200 U/L, lactate – 2.7 mmol/L
Application of Guidelines – Case Scenario #2

- Abdominal scan: marked peripancreatic fat stranding and fluid; mild enhancement of pancreas head; moderate wall thickening of duodenum
- Admitted from ED on i.v. fluids and insulin infusion
- Became somnolent with respiratory depression, sinus tachycardia, hypotensive (90/50 mm Hg)
- Lab values – significant for elevated lactate 8.6 mmol/L, serum creatinine 2.6 mg/dL

NCP 2016;31:334-341.
• Transferred to ICU, intubated, started on multiple vasopressor agents (norepinephrine, vasopressin), with ongoing fluid resuscitation
• Medications initiated included: dexmedetomidine, fentanyl, and meropenem
• General surgery determined there was no need for a surgical intervention at this time
Audience Response Question

Which of the following is the MOST appropriate next step for this patient?

A. No action is needed since this patient is at low nutritional risk
B. Enteral nutrition (EN) at full goal rate should be initiated as soon as possible
C. EN trophic feeds with parenteral nutrition (PN) should be initiated due to vasopressor requirements
D. Exclusive PN without EN should be initiated as soon as possible
Case Scenario #2

• A1. “Based on expert consensus, we suggest a determination of nutrition risk (e.g., NRS 2002, NUTRIC score) be performed on all patients admitted to the ICU for whom volitional intake is anticipated to be insufficient. High nutrition risk identifies those patients most likely to benefit from early EN therapy”
# Nutrition Risk Screening (NRS 2002)

<table>
<thead>
<tr>
<th>Nutrition status impairment</th>
<th>Severity of disease</th>
</tr>
</thead>
</table>
| **Score 0**  
Absent  
Normal nutritional status | **Score 0**  
Absent  
Normal nutritional requirements |

| **Score 1**  
Mild  
Weight loss > 5% in 3 months  
OR  
Food intake < 50-75% of normal | **Score 1**  
Mild  
Hip fracture; chronic patients with acute complications: cirrhosis, chronic obstructive pulmonary disease (COPD), chronic hemodialysis (HD), diabetes, cancer |

| **Score 2**  
Moderate  
Weight loss > 5% in 2 months  
OR  
BMI 18.5-20.5 + impaired general condition  
OR  
Food intake 25-50% of normal | **Score 2**  
Moderate  
Major abdominal surgery; stroke; severe pneumonia, hematologic malignancy |

| **Score 3**  
Severe  
Weight loss > 5% in 1 month  
OR  
BMI < 18.5 + impaired general condition  
OR  
Food intake 0-25% of normal | **Score 3**  
Severe  
Head injury  
Bone marrow transplant  
ICU (APACHE > 10) |

**Factors used to determine score** - A score of ≥3 identifies a patient for whom specialized nutrition therapy (EN or PN) should be considered. A score of ≥5 identifies a patient at high nutritional risk.
Case Scenario #2

Guideline Application

• L1a. Based upon expert consensus, we suggest that the initial nutrition assessment in acute pancreatitis evaluate disease severity to direct nutrition therapy.
  – Since disease severity may change quickly, we suggest frequent reassessment of feeding tolerance and the need for specialized nutrition therapy
  – Nutrition Care Plan: Due to evidence of SIRS and organ failure → severe acute pancreatitis

• L1c. We suggest patients with moderate to severe pancreatitis should have a naso/oroenteric feeding tube placed and EN started at a trophic rate and advanced to goal as fluid volume resuscitation is completed.
Case Scenario #2

- Nutrition Care Plan: Once patient was resuscitated and vasopressors were weaning, feeding was initiated at 20 mL/hr via nasoenteric feeding tube (FT) with tip confirmed to be in the stomach.
- Since completion of these guidelines, a new multicenter, RCT was conducted which does not support improved clinical outcomes with early EN as previous studies cited in the revised guidelines.
- In this case, EN was started early primarily because it was predicted that patient may require prolonged NPO status.
- L3b. We suggest EN be provided to the patient with severe acute pancreatitis by either the gastric or jejunal route, as there is no difference in tolerance and clinical outcomes between the two.

*NCP* 2016;31:334-341.
*JPEN* 2016;40:159-211.
Case Scenario #2

• B5. Based upon expert consensus, we suggest that in the setting of hemodynamic compromise or instability, EN should be withheld until the patient is fully resuscitated and/or stable. Initiation or reinitiation of EN may be considered with caution in patients undergoing withdrawal of vasopressor support.
  - Nutrition Care Plan: The patient was deemed hemodynamically stable due to decreasing vasopressor doses and MAPs > 65 mm Hg

• L2. We suggest using a standard polymeric EN formula upon initiation in a patient with severe pancreatitis. Although promising, there is currently insufficient data to recommend using an immune-enhancing formula in severe pancreatitis.
  - Nutrition Care Plan: A standard, non-fiber EN formula was selected for initiation and a modular protein supplement was used to increase the protein provision.
Case Scenario #2

Q4. Based upon expert consensus, we suggest that high-protein hypocaloric feeding be implemented in the care of obese patients to preserve lean body mass, mobilize adipose stores, and minimize metabolic complications of overfeeding.

- Nutrition care plan: High protein hypocaloric feeding impractical with available formulas.
- A low calorie, high-protein formula was not available on the formulary at this institution

Q5. Based upon expert consensus, we suggest for all classes of obesity that the goal of EN regimen should not exceed 65-70% of target energy requirements as measured by indirect calorimetry.

- If IC is unavailable, use 11 – 14 kcal/kg/day of ACTUAL BW for BMI 30 – 50 kg/m² and 22 – 25 kcal/kg/d of ideal body weight (IBW) for BMI > 50 kg/m²

Photo credit, Steve McClave, MD. Used with permission.
Case Scenario #2

• Q5. We suggest that protein should be provided in a range from 2 g/kg/d IBW for patients with BMI 30 – 39.9 kg/m² and up to 2.5 g/kg/d IBW for patients with BMI ≥ 40 kg/m².

• Nutrition Care Plan: Calculated BMI = 38 kg/m². The patient’s energy and protein needs were determined by a weight-based equation for the critically ill obese patient. He was prescribed approximately 1600 kcal (14 kcal/kg/d actual body weight).

• Estimated protein needs were 140 g or ≈2 g/kg/day IBW.

Photo credit, Steve McClave, MD. Used with permission.
Figure 1. Effect of protein intake (g/kg ideal body weight/d) on nitrogen balance in hospitalized obese patients from the combined databases of Choban et al and Dickerson et al. A significant correlation relationship was observed for each group. Patients with class 3 obesity (represented by the dashed line): nitrogen balance (g/d) = 7.3 × protein intake (g/kg IBW/d) – 13.8, r = .811, p < .001. Patients with classes I and II obesity (represented by solid line): nitrogen balance (g/d) = 11.0 × protein intake (g/kg IBW/d) – 19.1, r = .619, p < .001.

Figure 2. Effect of protein intake on nitrogen balance in obese traumatic ICU patients receiving hypocaloric enteral feeding (adapted from the data of Dickerson et al). The relationship between nitrogen balance and protein intake for classes I and II obesity patients (n = 12) is represented by the solid line: nitrogen balance = 7.7 × protein intake (g/kg IBW/d) – 18.1, r = .644, p < .001. The relationship for patients with class III obesity (n = 28) is represented by the dashed line: nitrogen balance = 4.6 × protein intake (g/kg IBW/d) – 13.0, r = .541, p < .05.
Case Scenario #2

• Monitoring tolerance of EN
  – D2a. We suggest that gastric residual volumes (GRVs) not be used as part of routine care to monitor ICU patients receiving EN.
  – D2b. For those ICUs where GRVs are still used, we suggest that holding EN for GRVs < 500 mL in the absence of other signs of intolerance should be avoided.

• Alternative strategies to be used to monitor critically ill patients receiving EN:
  – Daily abdominal exams
  – Review abdominal X-rays
  – Evaluate clinical risk factors for aspiration
Case Scenario #2

- Nutrition Care Plan: It was suspected that the patient may not tolerate EN due to previous X-ray evidence for reactive inflammation involving the duodenum and history of intolerance to oral intake PTA
- Critical care team followed the updated ICU EN protocol and monitored patient without use of routine GRVs
- ICU day #3, EN titration failed as evidenced by abdominal distention, abdominal pain, vomiting, NGT (≈ 800 mL)
- NGT remained to gravity drainage and a new nasoenteric FT placed in distal duodenum in hopes of improving EN tolerance
- Standard 1 kcal/mL EN formula was resumed and advanced to goal rate over the next 24 hrs
Case Scenario #3

• AS is a 64 yo female with a gastric outlet obstruction from gastric carcinoma
• PMH significant for peptic ulcer disease/gastroesophageal reflux disease requiring subtotal gastrectomy; COPD requiring supplemental oxygen
• Due to inability to eat, she has lost 40 pounds over past 6 months
• Anthropometric measurements: weight-38 kg, height-5 feet 2 inches, BMI=15.3, severe muscle and fat wasting in upper and lower extremities
Audience Response Question

Which of the following is the MOST appropriate next step for this patient?

A. No action is needed since this patient is at low nutritional risk

B. Enteral nutrition (EN) at full goal rate should be initiated as soon as possible

C. Exclusive PN initiated at 100% of energy requirements as soon as possible

D. Exclusive PN initiated 50% of energy requirements due to increased risk of refeeding syndrome
Case Scenario #3

- G2. Based upon expert consensus, in the patient determined to be at high nutrition risk (e.g., NRS 2002 score ≥ 5 or NUTRIC ≥ 6, with > 5 if no IL-6 value) or severely undernourished, when EN is not feasible, we suggest initiating exclusive PN as soon as possible following ICU admission.
  - Nutrition Care Plan: determined to be at high risk due to severe weight loss over 6 months (≈33% usual body weight) and evidence of severe muscle/fat wasting
  - Would have been ideal to start PN prior to surgery but the critical care team did not have this option
  - NRS 2002 = 5
  - PN initiated immediately after surgery due to poor nutritional status and predicted prolonged NPO status

*JPEN 2016;40:159-211.*
Case Scenario #3

- H2. We suggest that hypocaloric PN dosing (≤ 20 kcal/kg/day or 80% estimated energy needs) with adequate protein be considered in appropriate (high-risk or severely undernourished) patients requiring PN, initially over the first week of hospitalization
  - Prior to starting PN, electrolytes aggressively replenished due to increased risk for refeeding syndrome
  - Thiamine and folic acid were given prior to PN initiation and included in daily PN regimen
  - PN volume and sodium content were limited to ≈1000 mL/day and ≈ 0.45% normal saline due to fluid overload concerns
  - PN was initiated at 50% of estimated energy needs due to increased refeeding syndrome risk
Thiamine Deficiency (B1)

- Thiamine: water-soluble vitamin which may be depleted within 2-3 weeks
- Involved in conversion of pyruvate to acetyl CoA, which enters Kreb’s cycle to yield adenosine triphosphate
- Increased delivery of glucose via PN accelerates consumption of thiamine stores
- Pyruvate is converted to lactic acid in the absence of thiamine
FIGURE 1. Thiamine requirements in the metabolic pathways of glucose* 

GLYCOLYSIS 

GLUCOSE → PYRUVATE 

LACTATE 

Pyruvate dehydrogenase + THIAMINE 

ACETYL COENZYME A 

KREBS CYCLE 

Succinyl-CoA. → α-Ketoglutarate 

(α-Ketoglutarate dehydrogenase + THIAMINE)

Permission granted by SAGE on behalf of JPEN. Velez RJ et al. JPEN 1985;9:218.
Development of Thiamine Deficiency

- Time period for development of lactic acidosis: 1-4 weeks
- Presentation forms of thiamine deficiency:
  - “Wet” beriberi (cardiovascular system)
    - Venous congestive state (Na/H₂O retention)
  - “Dry” beriberi (nervous system)
    - Wernicke’s encephalopathy (ocular palsies, ataxia)
    - Korsakoff’s syndrome (amnesia, inability to learn)
  - Subclinical deficiency

Recommendations

• Administer multivitamins daily
• During a shortage of multivitamins:
  – 3-5 mg thiamine daily for hospitalized patients
  – 50 mg thiamine 3x/week for home patients
• Response
  – “wet” beriberi: improvement within 6-24 hours
  – “dry” beriberi: nystagmus, ataxia, and confusion may improve within days to weeks; Korsakoff’s psychosis may take 1-3 months

Case Scenario #3

13. Based upon expert consensus, we suggest that serum phosphate concentrations should be monitored closely and phosphate replaced appropriately when needed.

- The incidence of moderate to severe hypophosphatemia (≤ 1.5-2.2 mg/dL) is approximately 30% in the ICU
- Phosphorus is essential for ATP and 2,3-DPG
- Both ATP and 2,3-DPG are critical for optimal pulmonary function and diaphragmatic contractility
- Hypophosphatemia may be a cause of respiratory muscle weakness and failure to wean from the ventilator
- Specific protocols exist and have been published to replete patients with moderate to severe hypophosphatemia
Treatment Regimen for Hypophosphatemia

- Weight-based Phosphorus dosing algorithm
  - Mild (2.3-3 mg/dL) - 0.32 mmol/kg over 4-6 hours
  - Moderate (1.6-2.2 mg/dL) - 0.64 mmol/kg over 4-6 hours
  - Severe (≤ 1.5 mg/dL) - 1 mmol/kg over 8-12 hours
    - K+ < 4 mEq/L, KPO4 given
    - K+ > 4 mEq/L, NaPO4 given
    - Doses were infused at a rate not exceeding 7.5 mmol/hr

IV Concentrated Phosphate Shortage

- Consider oral or enteral phosphate products/supplements to replete or maintain serum phosphorus concentrations.
- Consider commercially available standardized, commercial PN products that contain phosphate.
- Reserve phosphates for pediatric and neonatal patients requiring PN.
- Reserve phosphates for those patients with a therapeutic medical need for phosphorus.
- Consider using IV organic phosphate injections, if available.
- Consider provision of daily IV fat emulsion to all PN patients as clinically appropriate. Note: IV fat emulsions contain 15 mmol/L of phosphate as egg phospholipids.

ASPEN website (accessed 2016 Aug 17)
https://www.nutritioncare.org/News/General_News/Parenteral_Nutrition_Electrolyte_and_Mineral_Product_Shortage_Considerations/
Key Takeaways

• Key Takeaway #1
  – Guidelines for Nutrition Support Therapy in Adult Critically Ill Patients include updated recommendations but also some recommendations that did not change due to a lack of any new evidence.

• Key Takeaway #2
  – There are still areas of controversy and disagreement, such as the issue of withholding SO-based IVFE for the first week of hospitalization.

• Key Takeaway #3
  – Refeeding syndrome is a preventable complication that may occur during reinstitution of nutrition in undernourished people.

• Key Takeaway #4
  – A.S.P.E.N. and ASHP websites should be consulted for parenteral nutrition (PN) shortage considerations in order to assist clinicians in coping with PN shortages for their patients.
Which of these practice changes will you consider making? (Select all that apply.)

A. Read the new A.S.P.E.N. guidelines described in this program
B. Educate staff about nutrition support needs in the critically ill
C. Educate about calculation of energy and protein requirements
D. Develop or update P&Ps for PN in critically ill adult patients