Brigham and Women's Hospital
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Fundamentals of Clinical Nutrition: Essentials for the Critical Care Specialist

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CONTINUING MEDICAL EDUCATION
DEPARTMENT OF MEDICINE

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Nutritional Status and Mortality in the Critically Ill*

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TABLE 3. Adjusted Associations Between Malnutrition and Mortality ($n = 6,518$)

Outcome	Mortality OR (95% CI)[a]	p
30-d mortality		
Adjusted[b]		
Nonspecific malnutrition	1.17 (1.01–1.37)	0.041
Protein-energy malnutrition	2.10 (1.70–2.59)	< 0.001
Adjusted + PS		
Nonspecific malnutrition	1.16 (1.00–1.36)	0.053
Protein-energy malnutrition	2.00 (1.62–2.48)	< 0.001
PS-matched cohort[c]		
Nonspecific malnutrition	1.05 (0.88–1.26)	0.56
Protein-energy malnutrition	2.04 (1.56–2.66)	< 0.001
90-d mortality		
Adjusted[d]		
Nonspecific malnutrition	1.46 (1.27–1.67)	< 0.001
Protein-energy malnutrition	2.87 (2.36–3.48)	< 0.001
Adjusted + PS		
Nonspecific malnutrition	1.44 (1.25–1.65)	< 0.001
Protein-energy malnutrition	2.62 (2.15–3.19)	< 0.001
PS-matched cohort[e]		
Nonspecific malnutrition	1.29 (1.10–1.50)	0.002
Protein-energy malnutrition	2.64 (2.07–3.37)	< 0.001

Crit Care Med 2015; 43:2605-2615

CASE ONE

A 50 y.o. obese female is admitted to the ICU with sepsis after a leak at the gastro-jejunal anastomosis one day after gastric bypass surgery. Regarding her nutrition:

A. Specialized nutrition support will not be necessary since she is morbidly obese and is "protected" against nutritionally related complications.

B. TPN should be initiated immediately as she is malnourished.

C. TPN initiation, if necessary, can wait for 7-10 days while the severity of the leak and possibility of enteral nutrition down the line are determined.

D. TPN is contra-indicated in the obese septic individual due to the high risk of hyperglycemia and associated complications.

E. If specialized nutrition support is necessary, tube feeding is not an option as enteral access in post gastric bypass patients is not possible.

A.S.P.E.N. Clinical Guidelines: Nutrition Support of Hospitalized Adult Patients With Obesity

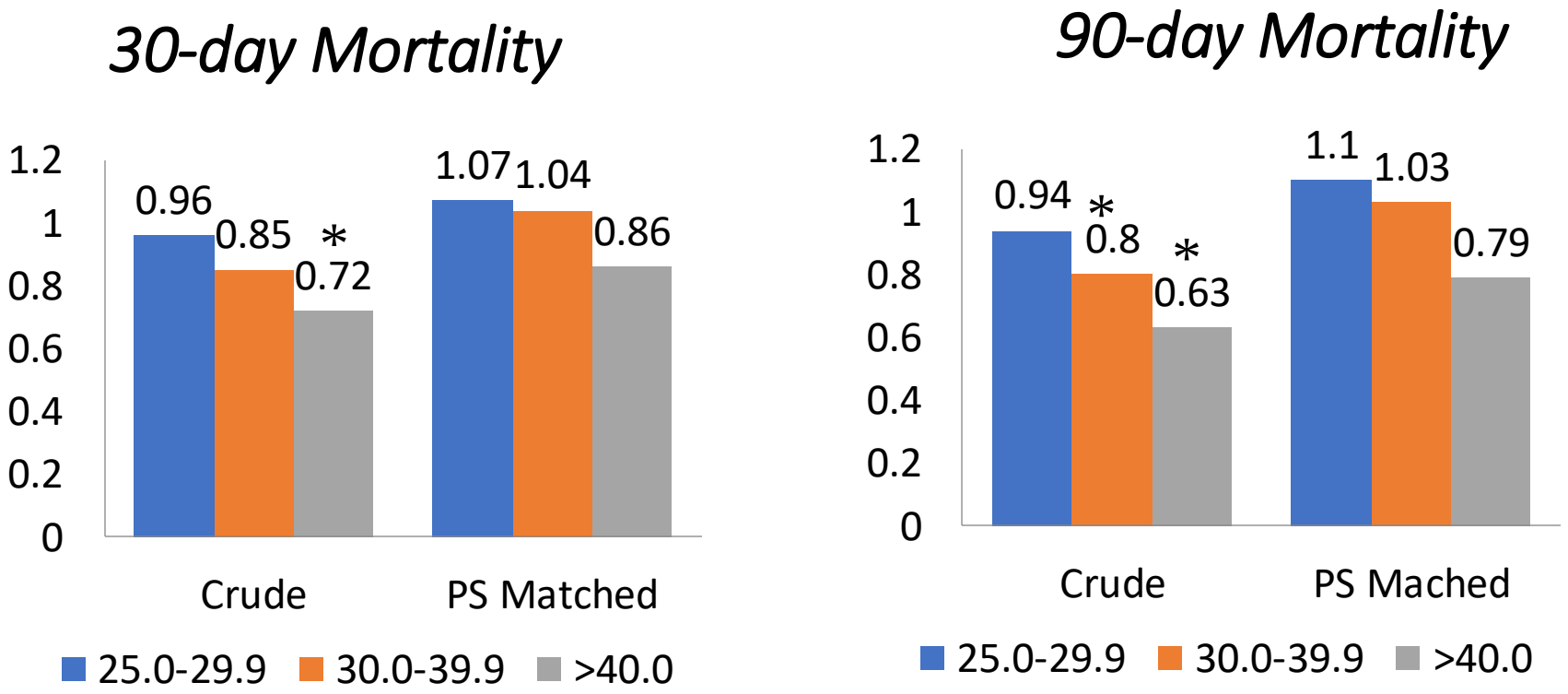
Table 3. GRADE Table Question 1: Do Clinical Outcomes Vary Across Levels of Obesity in Critically Ill or Hospitalized Non-ICU Patients?

Comparison	Outcome	Quantity, Type of Evidence	Findings	Grade for Outcome	Overall Evidence GRADE
ICU patients					
Obese vs optimal BMI	Mortality (large studies)	8 OBS	1 increased[21] 5 decreased[23,35,42,44,45] 2 no difference[32,46]	Low	Low
	Hospital LOS (large studies)	4 OBS	3 increased[22,29,45] 1 no difference[46]	Low	
	Complications	6 OBS	5 increased[25,37,46-48] 1 no difference[32]	Low	
BMI ≥ 40 kg/m^2 vs optimal BMI	Mortality (large studies)	4 OBS	1 decreased[44] 3 no difference[22,23,45]	Low	
	Hospital LOS (large studies)	4 OBS	2 increased[22,29] 2 no difference[45,46]	Low	
Non-ICU patients					
Obese vs optimal BMI	Mortality	2 OBS	1 increased[49] 1 no difference[91]	Low	

ICU, intensive care unit; LOS, length of stay; OBS, observational study.

(*JPEN J Parenter Enteral Nutr*. 2013;37:714-744)

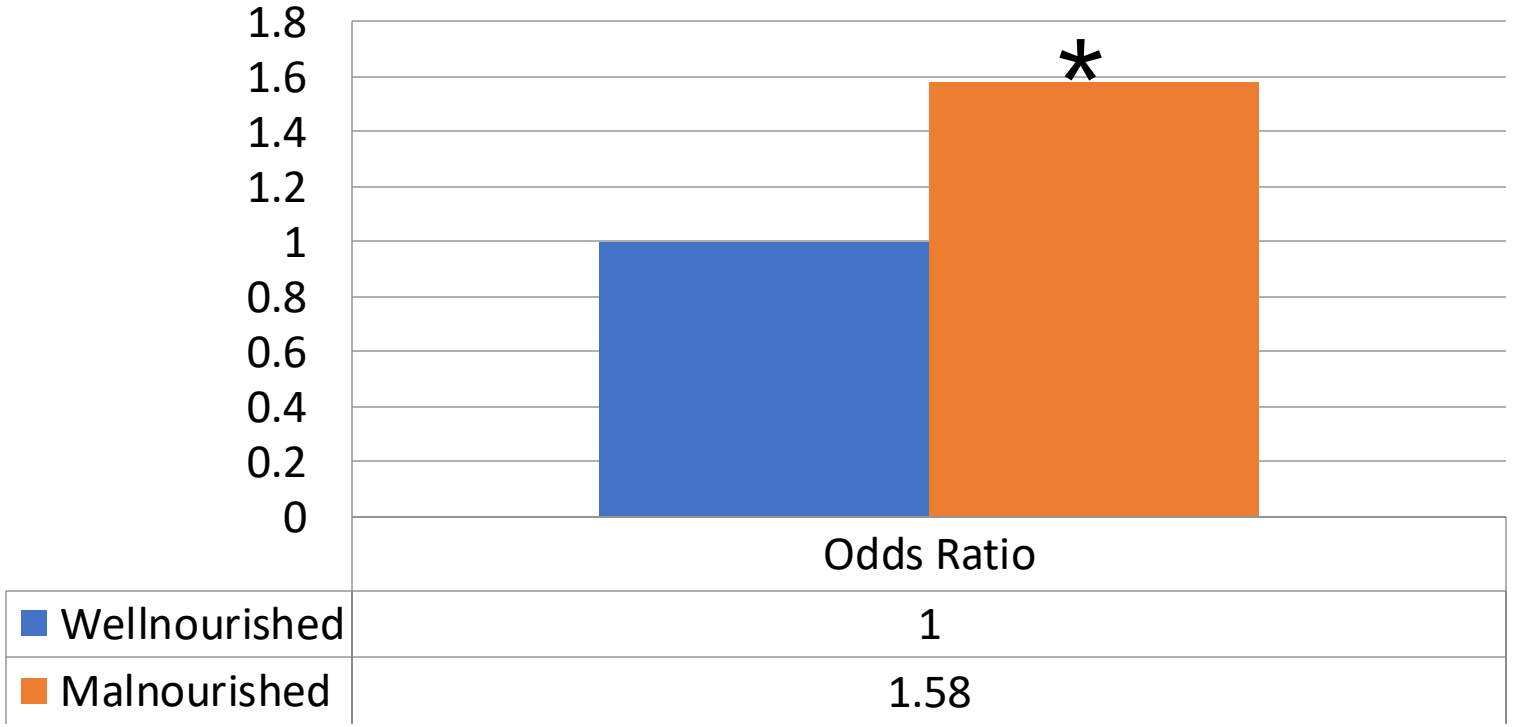
Crude and Adjusted Mortality Odds Ratio by BMI Category



**p<0.05 versus BMI 18.5-24.9. PS matched (n=1,777 obese and 1,777 non-obese) adjusts for age, gender, race, medical versus surgical ICU, Deyo-Charlson Index and nutrition status.*

Crit Care Med 2015;43:87-100

Adjusted Odd Ratio for 30-day Mortality in Obese Critically Ill patients with and without Malnourishment



**p =0.001 versus well nourished.*

Crit Care Med 2015;43:87-100

A.S.P.E.N. Clinical Guidelines: Nutrition Support of Hospitalized Adult Patients With Obesity

3. Are clinical outcomes improved with hypocaloric, high protein diets in hospitalized patients with obesity?	3a. Clinical outcomes are at least equivalent in patients supported with high protein, hypocaloric feeding to those supported with high protein, eucaloric feeding. A trial of hypocaloric, high protein feeding is suggested in patients who do not have severe renal or hepatic dysfunction. Hypocaloric feeding may be started with 50%-70% of estimated energy needs or < 14 kcal/kg actual weight. High protein feeding may be started with 1.2 g/kg actual weight or 2-2.5 g/kg ideal body weight, with adjustment of goal protein intake by the results of nitrogen balance studies.	Recommendation: Weak Evidence: Low
	3b. Hypocaloric, low protein feedings are associated with unfavorable outcomes. Clinical vigilance for adequate protein provision is suggested in patients who do not have severe renal or hepatic dysfunction.	Recommendation: Weak Evidence: Low

(*JPEN J Parenter Enteral Nutr.* 2013;37:714-744)

A.S.P.E.N. Clinical Guidelines: Nutrition Support of Hospitalized Adult Patients With Obesity

1. Do clinical outcomes vary across levels of obesity in critically ill or hospitalized non-ICU patients?	1a. Critically ill patients with obesity experience more complications than patients with optimal BMI levels. Nutrition assessment and development of a nutrition support plan is recommended within 48 hours of ICU admission.	Recommendation: Strong Evidence: Low
	1b. All hospitalized patients, regardless of BMI, should be screened for nutrition risk within 48 hours of admission, with nutrition assessment for patients who are considered at risk.	Recommendation: Strong Evidence: Low

(*JPEN J Parenter Enteral Nutr*. 2013;37:714-744)

CASE ONE

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E. If specialized nutrition support is necessary, tube feeding is not an option as enteral access in post gastric bypass patients is not possible.

Nutrition Assessment

- **Obtain medical history, laboratory data and history of recent weight change.**
- **Determine nutritional status: well-nourished versus mild, moderate or severe malnutrition.**
- **Calculate calorie and protein requirements.**
- **Make recommendation regarding nutritional intervention (if any).**

Nutrition Assessment: Classification of Malnutrition

Percentage of Usual Body Weight:

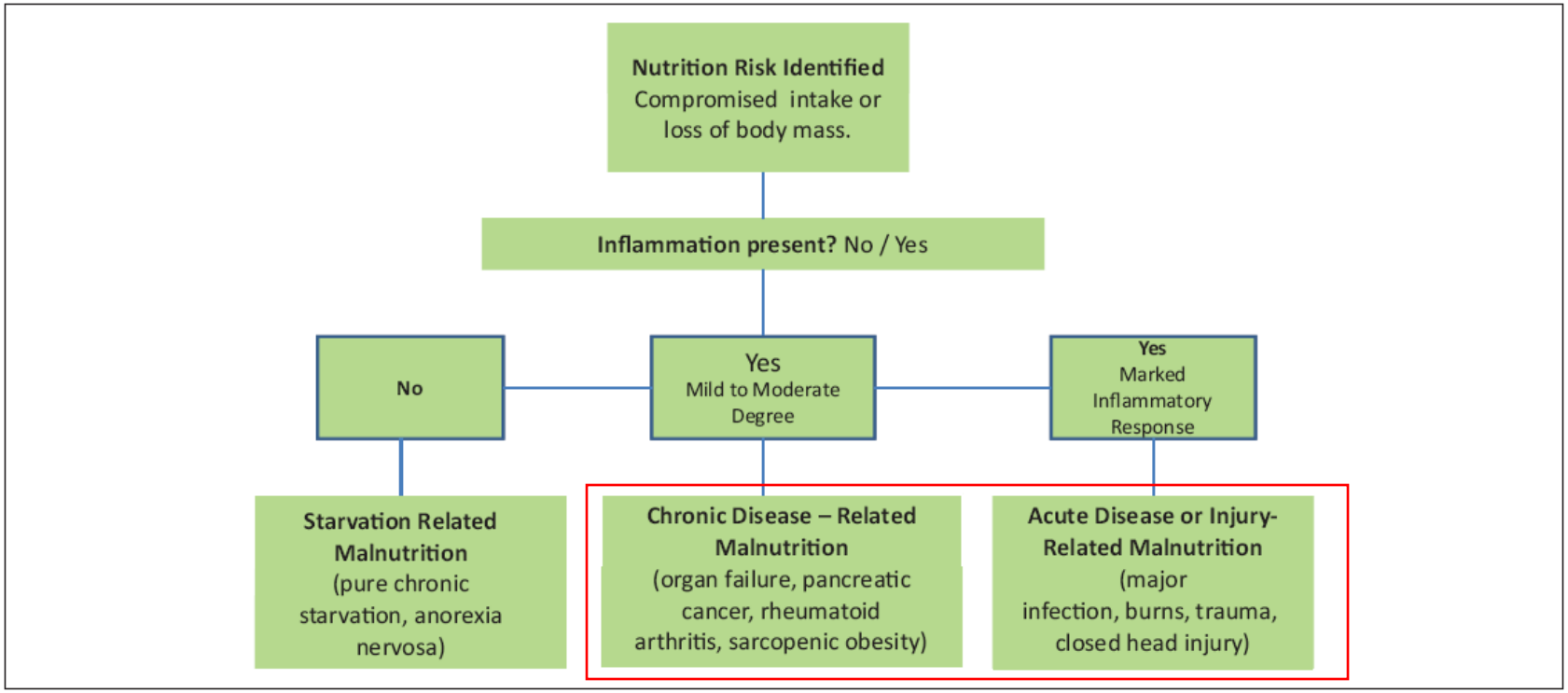
85-95% **"Mild Malnutrition"**

75-84% **"Moderate Malnutrition**

<74% **"Severe Malnutrition"**

Predictive equations (e.g., Nutritional Risk Index) and laboratory values (e.g., prealbumin)

Etiology-Based Malnutrition Diagnoses



From: White JV et al. Consensus statement: Academy of Nutrition and Dietetics and American Society for Parenteral and Enteral Nutrition: Characteristics recommended for the identification and documentation of adult malnutrition (undernutrition). JPEN 2012

Nutrition Assessment: *Caveats*

- Traditional indices of nutrition status (e.g., albumin, pre-albumin) may be unreliable in acutely ill patients or those with fluid overload (e.g., ascites).
- Weight may be an unreliable indicator of nutritional status (e.g., advanced liver disease).
- Hand grip strength, skin fold thickness, mid-arm circumference may be more reliably used to assess lean body mass in some clinical situations.
- DEXA is gold standard to assess body composition.

Nutrition Assessment: Estimating Energy Requirements

- **There are many, many ways to estimate caloric needs.**
- **Predictive formulas exist for different patient populations e.g., ICU, obese, elderly, amputees, etc.**
- **Two of the most common ways to estimate caloric needs are:**
  - **Harris-Benedict equation**
  - **kcals/kg**

Guidelines for the provision of nutrition support therapy in the adult critically ill patient: The American Society for Parenteral and Enteral Nutrition

Question 1. In adult critically ill patients, does provision of higher vs lower energy intake impact clinical outcomes?

Recommendation: No significant difference in clinical outcomes was found between patients with higher vs lower levels of energy intake. We suggest feeding between 12 and 25 kcal/kg (ie, the range of mean energy intakes examined) in the first 7–10 days of ICU stay.

J Parenter Enteral Nutr. 2022;46:12–41.

Nutrition Assessment: Determining Daily Caloric Needs

Calorie needs based on predictive equations and weight alone can be very inaccurate.

Such estimates may be off by 20% or more in many populations (e.g., obesity, burns, fluid overload, amputees, head trauma)

"Gold Standard": Indirect Calorimetry (Metabolic Cart study) to determine REE.

Indirect Calorimetry

Assessment of resting energy expenditure (REE) and respiratory quotient (RQ) by measurement of oxygen consumption (VO_2) and carbon dioxide production (VCO_2)

Weir Equation

Complete:

- **REE (kcal/day)= [3.94 (VO_2)+1.1(VCO_2)] x 1.44 – 2.17(UN)**

Abbreviated:

- **REE (kcal/day)= [3.94 (VO_2)+1.1(VCO_2)] x 1.44**

- **Daily *Caloric* requirement based on REE is:**
  - **REE x activity factor (1.0-1.3)**

Why Metabolic Cart Studies May Be Inaccurate

All exhaled gas is not collected

- **Leaks around the tracheostomy tube cuff**
- **Chest tubes**

Measurements made during dialysis

- **The CO_2 is dialyzed off**

Nitric Oxide therapy

Steady state not achieved

Guidelines for the provision of nutrition support therapy in the adult critically ill patient: The American Society for Parenteral and Enteral Nutrition

Question 2. In adult critically ill patients, does provision of higher as compared with lower protein intake impact clinical outcomes?

Recommendation: There was no difference in clinical outcomes in the relatively limited data. Because of a paucity of trials with high-quality evidence, we cannot make a new recommendation at this time beyond the 2016 guideline suggestion for 1.2–2.0 g/kg/day.

J Parenter Enteral Nutr. 2022;46:12–41.

CASE TWO

A 62 y.o. male was admitted to the ICU with urosepsis and aspiration pneumonia. He was initially hypotensive and required a low dose pressor and intubation to stabilize. The pressor is slowly being weaned off. He had poor po intake for a month prior to admission. Regarding his nutrition:

A. Specialized nutrition support is not indicated until he has been hospitalized for 7-10.

B. TPN should be avoided because he is septic and TPN may exacerbate his bacteremia.

C. TPN should be started immediately as he has been without adequate nutrition for 30 days and this is the best route for feeding given this clinical scenario.

D. Enteral nutrition should be considered and carefully initiated immediately via a naso-enteric tube.

E. Enteral nutrition is contra-indicated because he is hypotensive and on pressor support. The EN may precipitate bowel ischemia.

Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.)

C1. Based on expert consensus, we suggest that patients who are at low nutrition risk with normal baseline nutrition status and low disease severity (eg, NRS 2002 ≤3 or NUTRIC score ≤5) who cannot maintain volitional intake do not require specialized nutrition therapy over the first week of hospitalization in the ICU.

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February 2016 159–211

Guidelines for the provision of nutrition support therapy in the adult critically ill patient: The American Society for Parenteral and Enteral Nutrition

Question 3: In adult critically ill patients who are candidates for EN, does similar energy intake by PN vs EN as the primary feeding modality in the first week of critical illness impact clinical outcomes?

Recommendation: There was no significant difference in clinical outcomes between early exclusive PN and EN during the first week of critical illness. As PN was not found to be superior to EN and no differences in harm were identified, we recommend that either PN or EN is acceptable.

J Parenter Enteral Nutr. 2022;46:12–41.

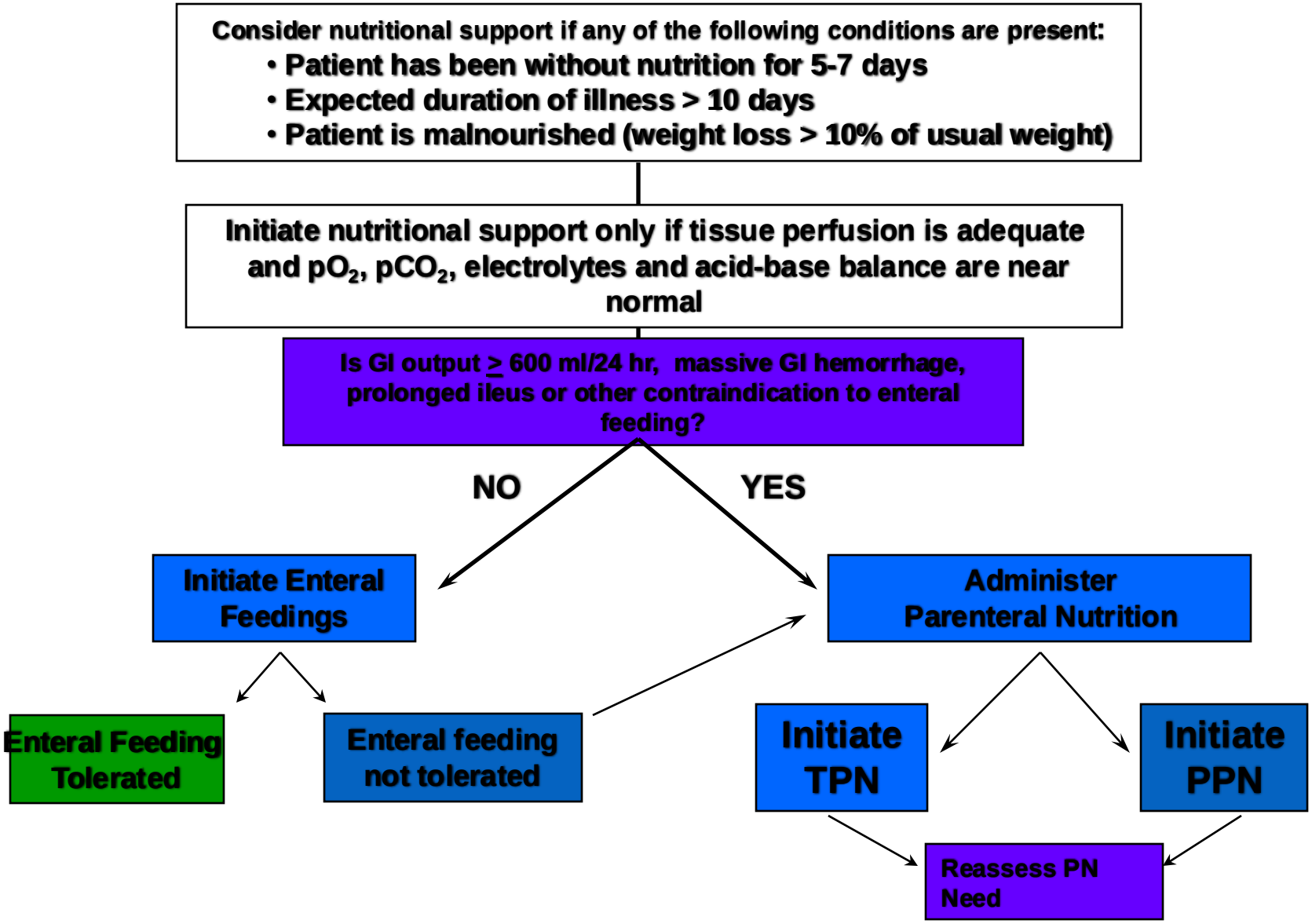
CONSENSUS STATEMENT

When is enteral nutrition indicated?

1. What is the optimal time frame to initiate enteral nutrition (EN) in the high-risk nutrition patient, the malnourished patient, and the stable well-nourished patient?
   A. Initiate EN within 24–48 h of admission to the hospital, including the intensive care unit (ICU), in the patient who is at high risk for malnutrition or who is malnourished.
   B. A delay in initiation of EN can be considered in hospitalized patients who are low risk, well nourished, and expected to resume volitional oral intake within 5–7 days of admission.
   C. Advance EN cautiously in patients at risk for refeeding and in patients with symptoms of gastrointestinal (GI) intolerance.

J Parenter Enteral Nutr. 2022;1–27.

Determining Route of Feeding



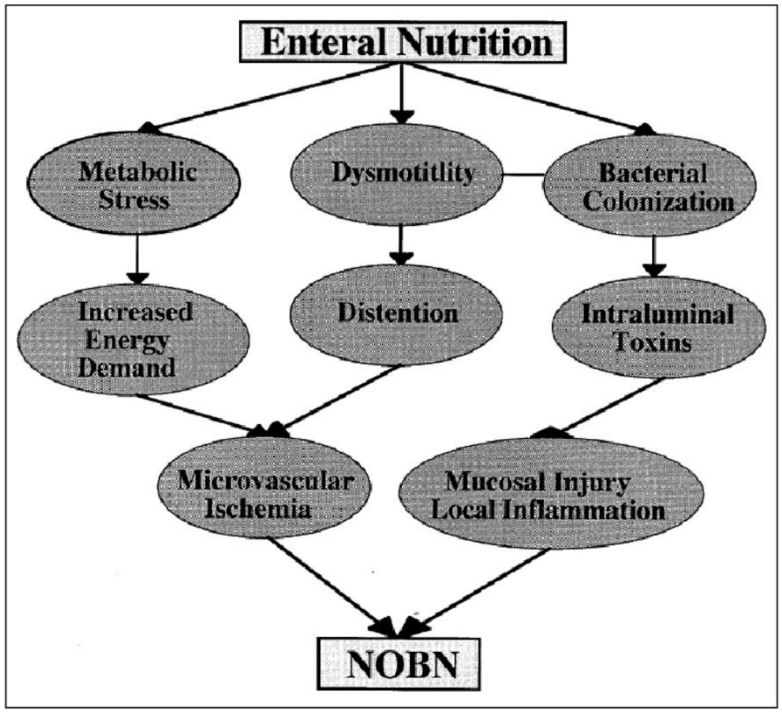


Figure 1. Non-occlusive bowel necrosis may result when enteral feeding leads to microvascular ischemia, mucosal injury, or local inflammation. Feeding the gut may cause some metabolic stress, dysmotility, and/or bacterial colonization that drive the aforementioned processes (13). Reproduced with permission from Elsevier Publishing.

Non-occlusive bowel necrosis is the final common outcome for both severe gut micro-vascular ischemia and mucosal injury and inflammation

Signs/Sx's Concerning for NOBI

- Abdominal distension
- Ileus or failure to have a bowel movement
- High oro- or nasogastric tube output
- Bloating and cramps
- Worsening hemodynamic status after initiation of feeds
- *Normal LA level does not rule out impending disaster*

Concerning radiographic signs:

- Dilated, thickened loops of bowel
- Pneumatosis intestinalis
- Portal venous gas
- *Normal imaging does not rule out bowel ischemia*

CONSENSUS STATEMENT

When is enteral nutrition indicated?

5. When should early EN be initiated in hemodynamically unstable patients?
   A. Vasopressor administration is not a contradiction to providing early EN with careful monitoring.
      i. Consider the following factors when administering EN concomitantly with vasopressor administration: type of vasopressor agent, vasopressor equivalent dosage, timing of EN, and feeding location.
      ii. Consider trophic only or holding EN if vasopressor dose equivalent (VDE) score is >12.

J Parenter Enteral Nutr. 2022;1–27.

CASE TWO

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A. Specialized nutrition support is not indicated until he has been hospitalized for 7-10 days and determined to be unable to adequately nourish himself by the po route.

B. TPN should be avoided because he is septic and TPN may exacerbate his bacteremia.

C. TPN should be started immediately as he has been without adequate nutrition for 30 days and this is the best route for feeding given this clinical scenario.

D. Enteral nutrition should be considered and carefully initiated immediately via a naso-enteric tube.

E. Enteral nutrition is contra-indicated because he is hypotensive and on pressor support. The EN may precipitate bowel ischemia.

Tube Feeding Complications

Tube Related

Perforation

Bleeding

Malposition/Migration

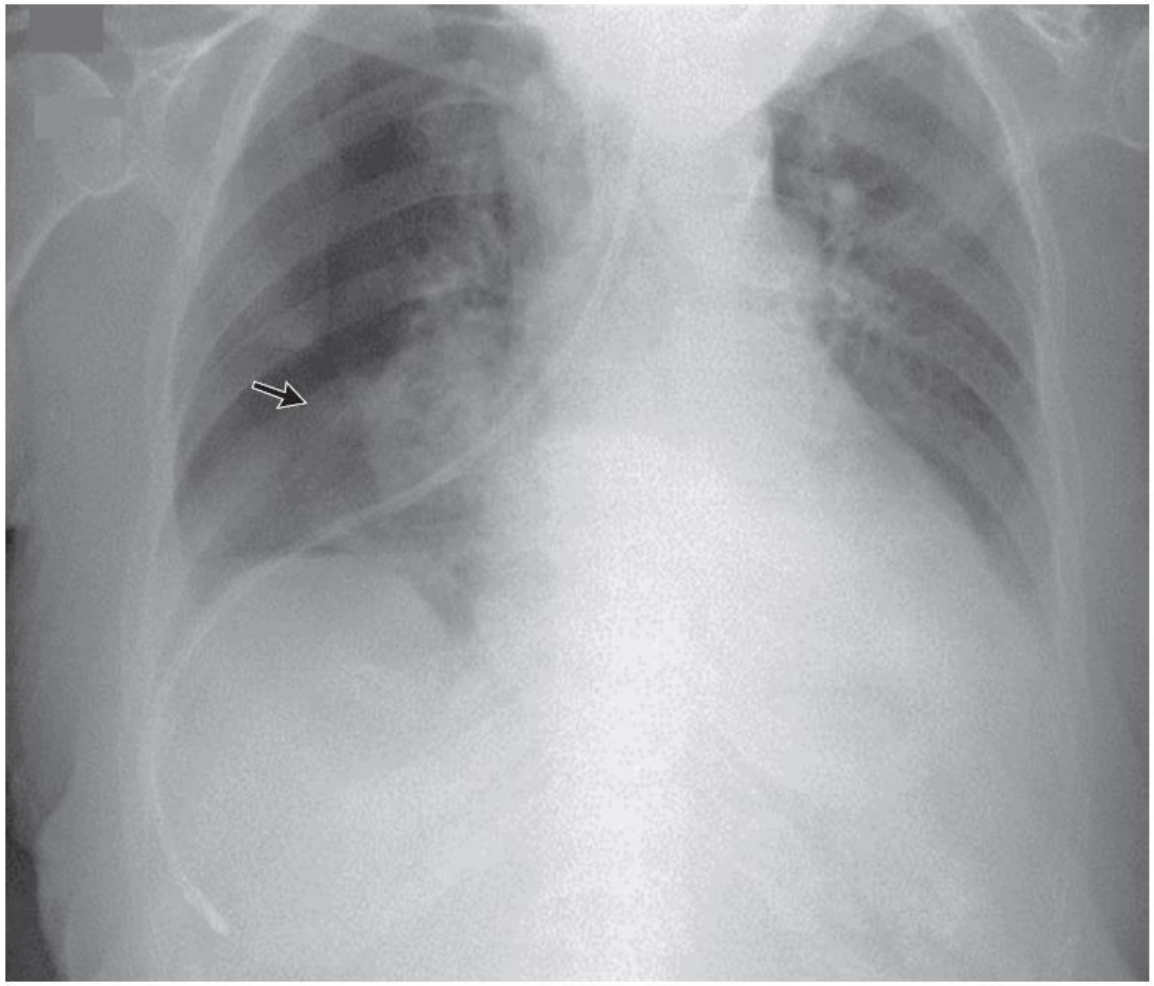
Obstruction

Wound Infection

Tube "Falls Out"

Feeding Related

- **Nausea/Vomiting**
- **Diarrhea**
- **Abdominal Distention**
- **Bowel Necrosis**
- ***Aspiration***



Management of Critically Ill Patients with Respiratory Failure

X-ray confirmation of enteral feeding tube placement is recommended to avoid a potentially lethal complication.

Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.)

D2a. We suggest that GRVs not be used as part of routine care to monitor ICU patients receiving EN.

D2b. We suggest that, for those ICUs where GRVs are still utilized, holding EN for GRVs <500 mL in the absence of other signs of intolerance (see section D1) should be avoided.

[Quality of Evidence: Low]

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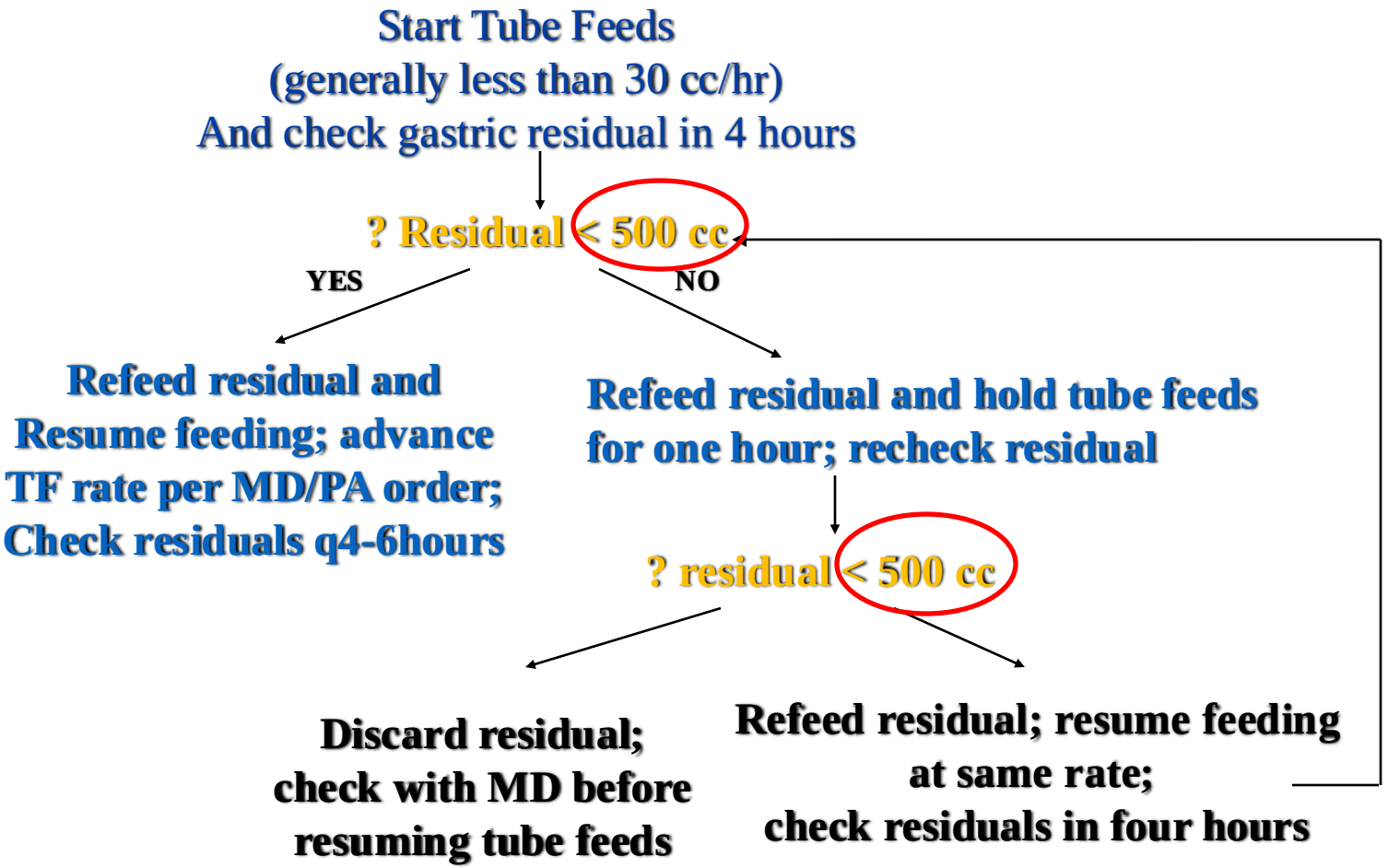
Gastric Residual Protocol



CONSENSUS STATEMENT

When is enteral nutrition indicated?

TABLE 1 Relative and absolute contraindications for enteral nutrition

Relative contraindications	Absolute contraindications
Severe hemodynamic instability	Bowel obstruction
Ileus	Major gastrointestinal ischemia
Vomiting/diarrhea	High-output fistula
Upper gastrointestinal bleeding	

Consensus Recommendation

When Is Parenteral Nutrition Appropriate?

Nutritionally-At-Risk Adult

- Involuntary weight loss of 10% of usual body weight within 6 months or 5% within 1 month
- Involuntary loss of 10 lb within 6 months
- Body mass index (BMI) less than 18.5 kg/m^2
- Increased metabolic requirements
- Altered diets or diet schedules
- Inadequate nutrition intake, including not receiving food or nutrition products for more than 7 days[6]

J Parenter Enteral Nutr. 2017;41:324-377)

Initiating TPN

- Establish appropriate and dedicated venous access.
- Determine macronutrient concentrations and administer approximately 20% of calories as Protein, 20% as Fat, and 60% as Carbohydrate.
- Determine fluid requirements (30cc/kg).
- Correct electrolyte abnormalities to avoid re-feeding syndrome: Mg, K, PO4.
- Start with approximately half of goal solution and advance toward goal as tolerated.

What type of EN should be used in ALI/ARDS patients ?

Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.)

I1. We suggest that specialty high-fat/low-carbohydrate formulations designed to manipulate the respiratory quotient and reduce CO_2 production not be used in ICU patients with acute respiratory failure (not to be confused with recommendation E3).

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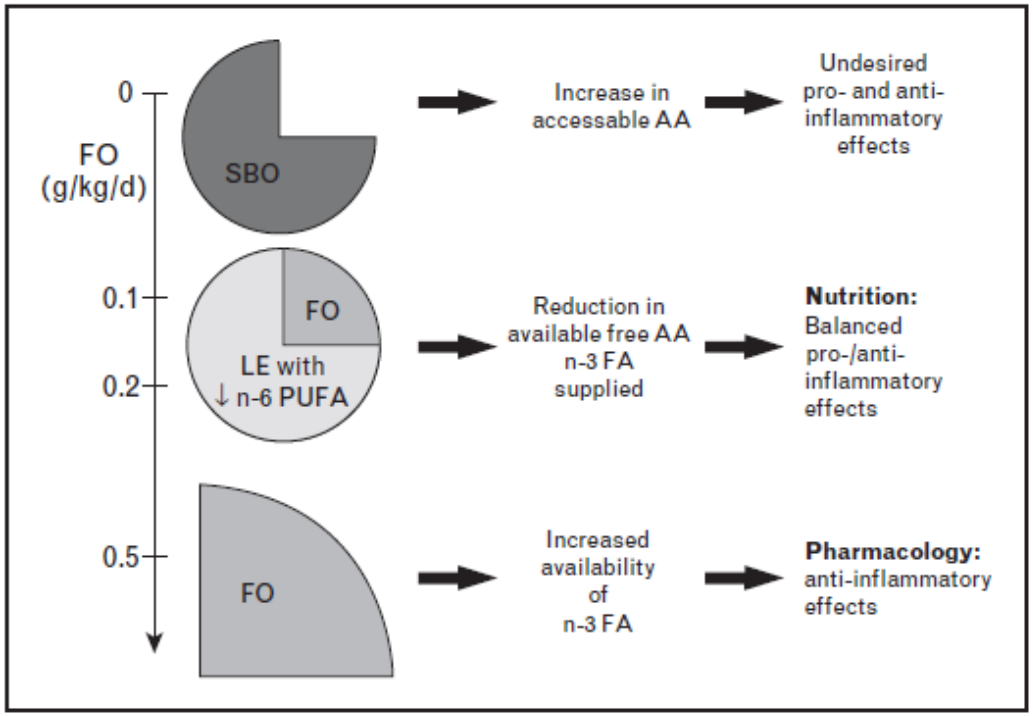
Should ALI/ARDS Patients receive an anti-inflammatory lipid EN formula with antioxidants ?

Fish oil in critical illness

Konstantin Mayer and Werner Seeger

Figure 1 Effects of different amounts of fish oil-based lipid emulsions supplied to critical ill patients



Current Opinion in Clinical Nutrition and Metabolic Care 2008, 11:121–127

Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.)

E3. We cannot make a recommendation at this time regarding the routine use of an enteral formulation characterized by an anti-inflammatory lipid profile (eg, omega-3 FOs, borage oil) and antioxidants in patients with ARDS and severe ALI, given conflicting data.

[Quality of Evidence: Low to Very Low]

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Peripheral Parenteral Nutrition

- **Useful on limited basis.**
- **Patient must be able to tolerate at least 2 liters of fluid per day.**
- **Two liters per day provides only 1040 calories.**
- **May supplement inadequate enteral feeding.**
- **Best used on short term basis.**

Extravasation of Peripherally Administered Parenteral Nutrition

Belloni B, Andres C. N Engl J Med 2011;364:e20.

Common TPN-Associated Complications

- Hyperglycemia
- Hypoglycemia
- Electrolyte Abnormalities (Renal Failure)
- Refeeding Syndrome
- Infection
- PN-Associated Liver Dysfunction

Fundamentals of Clinical Nutrition in the ICU: *Key Points and Summary*

- **Nutrition intervention begins with assessment.**
- **Assessment includes anthropometrics, medical history, and lab evaluations.**
- **Determine the % usual body weight and time course of weight.**
- **Nutritional status determined from above information.**

Fundamentals of Clinical Nutrition in the ICU
Key Points and Summary

- **Not all patients require nutrition intervention (i.e. tube feeds or PN)**
- **If nutritional intervention likely or necessary, then calculate protein and energy needs.**
- **Energy needs based on predictive formulas (e.g., Harris-Benedict) or indirect calorimetry, the "gold standard."**
- **Protein needs based on clinical situation and about 1.0-1.5 g/kg for acutely ill.**

Fundamentals of Clinical Nutrition in the ICU

Key Points and Summary

- If nutrition intervention necessary, then tube feeds are much preferred over PN.
- If EN not possible for extended period, then PN should be initiated *if* duration of PN anticipated to be for at least 5 days.
- Overfeeding can be as deleterious as underfeeding.
- Hyperglycemia should be avoided.

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