
BRIGHAM HEALTH
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Fundamentals of Clinical Nutrition:
Essentials for the Critical Care Specialist
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- Research Focus: Surgical Metabolism; Improving Surgical Outcomes in Bariatric Surgery

I have no financial disclosures or conflicts of interest pertaining to this presentation

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

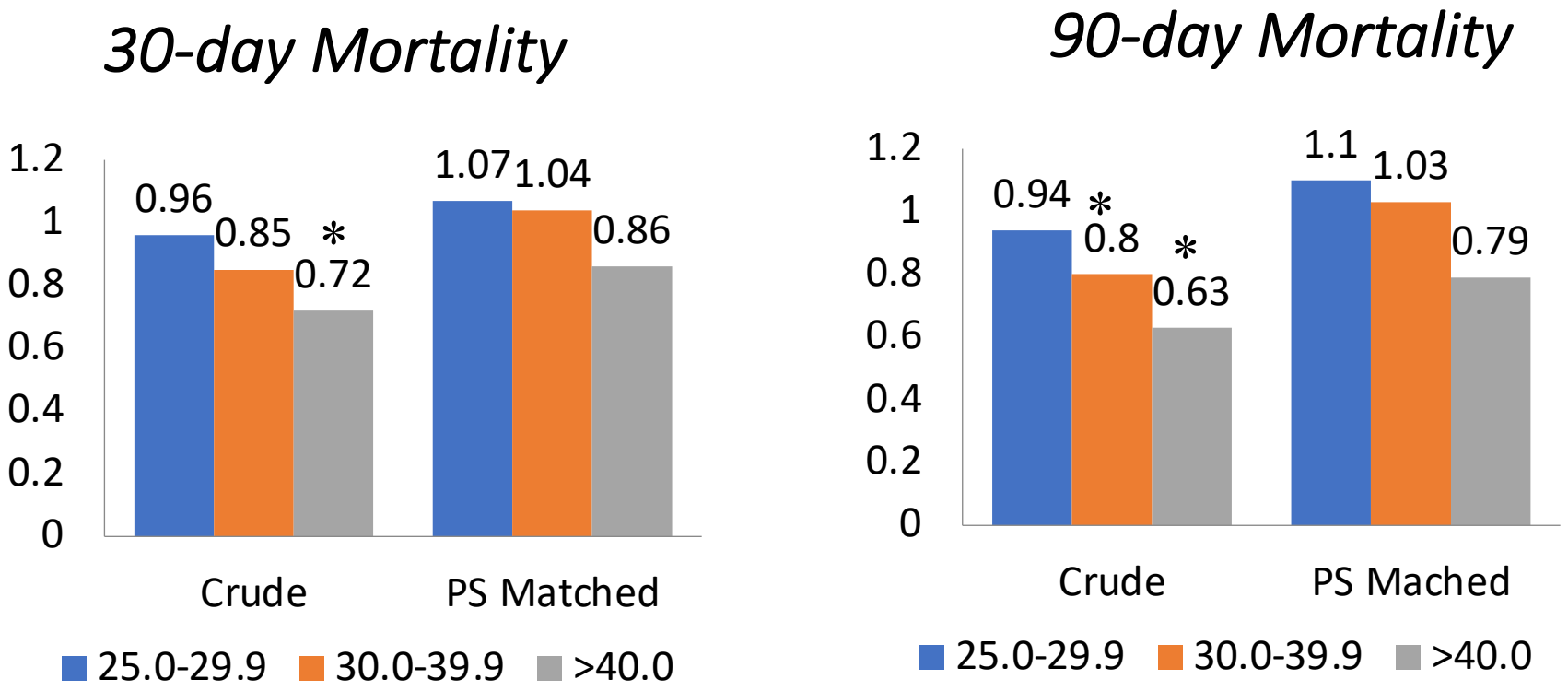
Table 3. GRADE Table Question 1: Do Clinical Outcomes Vary Across Levels of Obesity in Critically Ill or Hospitalized Non-ICU Patients?

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)

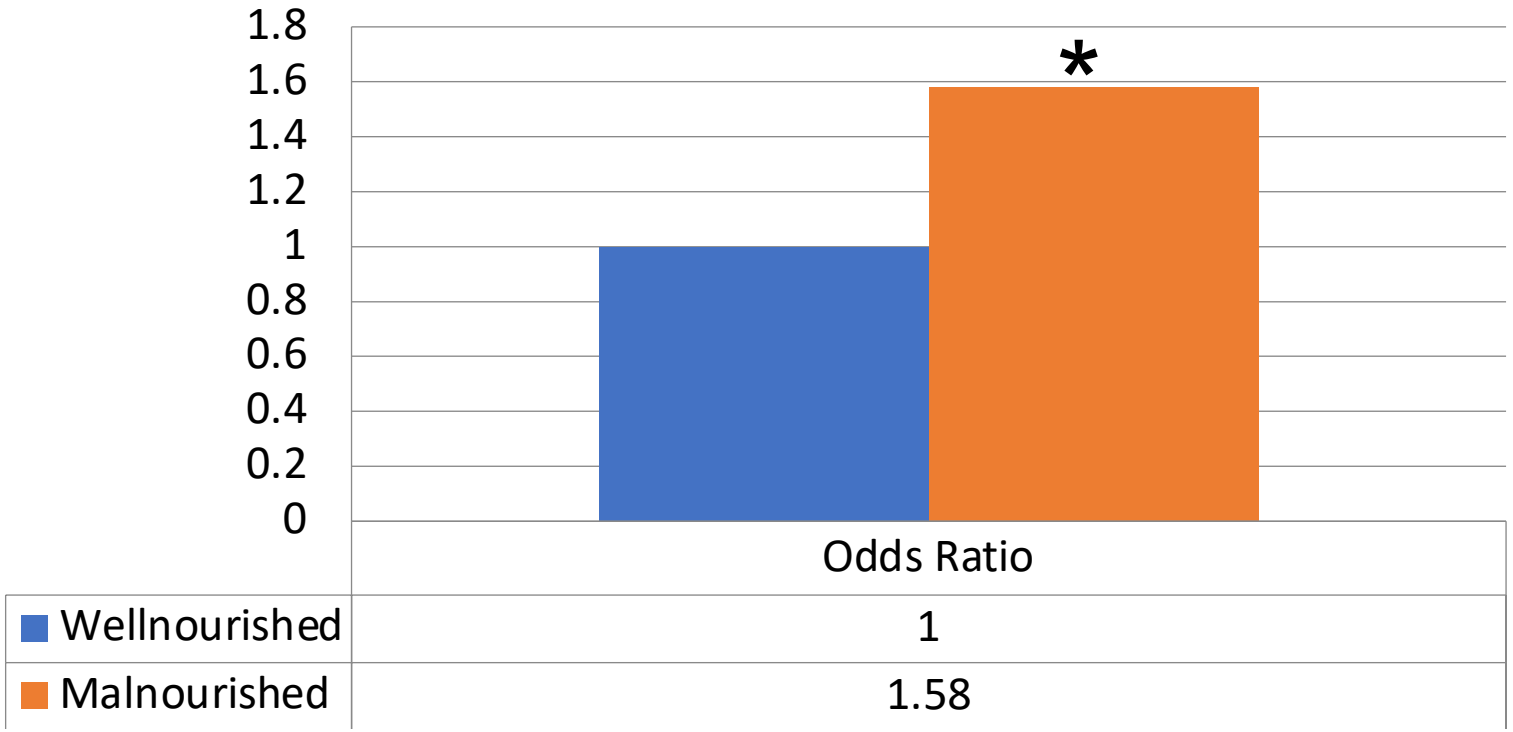
Crude and Adjusted Mortality Odds Ratio by BMI Category



**p<0.05 versus BMI 18.5-24.9. PS matched (n=1,777 obese and 1,77 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)

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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:

Morbidly obese patients can become malnourished and malnourished obese patients in the ICU have worse outcomes compared to well nourished obese patients. However, as the patient is only one day post-op, she is not currently malnourished and does not require immediate initiation of specialized nutrition support. TPN can be safely given to obese septic individuals, if indicated, with appropriate monitoring and control of glucose. Tube feeding is possible in gastric bypass patients via a number of different enteral access routes.

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)

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:

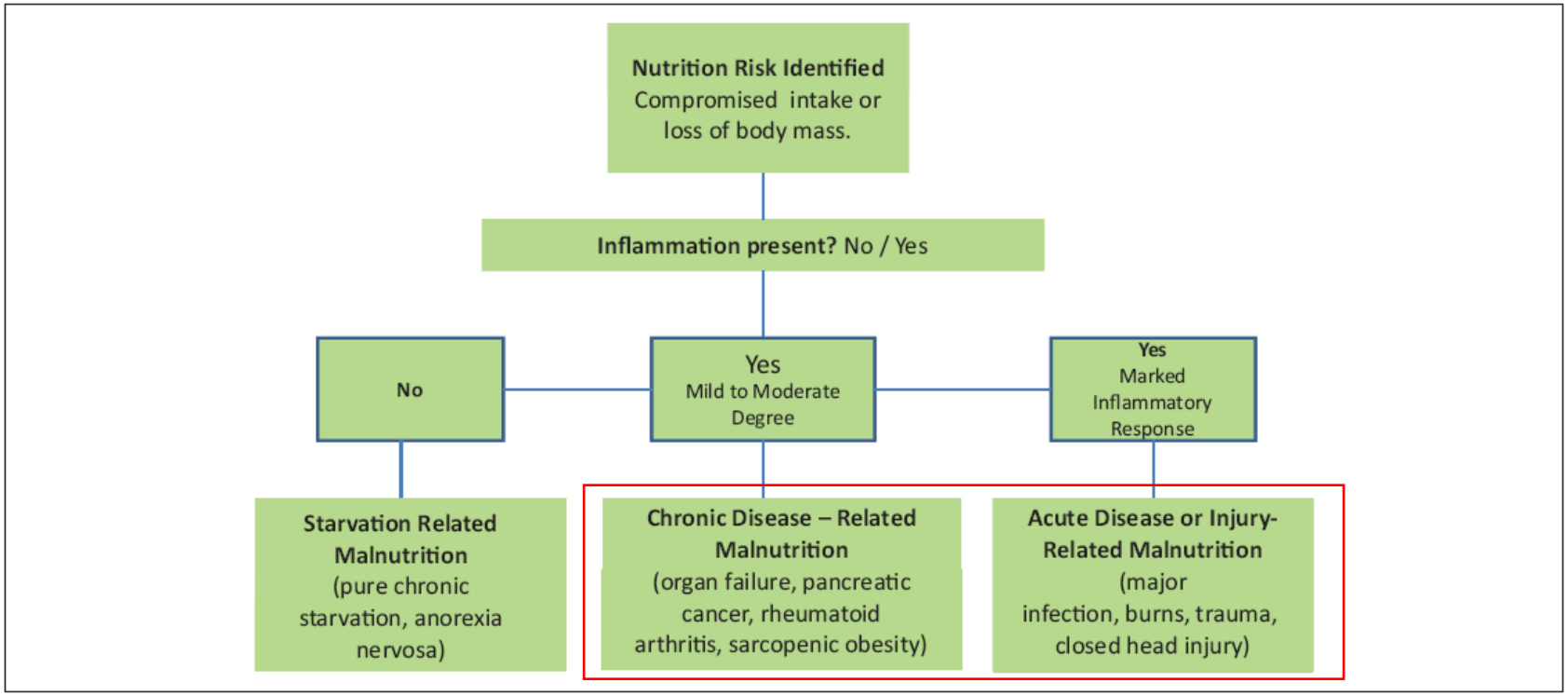
85-95% **"Mild Malnutrition"**

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

Nutrition Assessment: Determining Daily Caloric Needs

Predictive formulas may be used to estimate BMR.

Harris-Benedict Equations:

***Male* BMR=66.47 + 13.75(W) + 5.0 (H) - 6.75 (A)**

***Female* BMR= 655.1 + 9.56 (W) + 1.85 (H) - 4.68 (A)**

Daily *Caloric* requirement based on BMR is:

BMR x Activity (1.0-1.3) x Disease Stress (1.2-2.1)

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 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.)

A3b. Based on expert consensus, in the absence of IC, we suggest that a published predictive equation or a simplistic weight-based equation (25–30 kcal/kg/d) be used to determine energy requirements. (See section Q for obesity recommendations.)

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Nutrition Assessment: Determining Daily Protein Needs

Condition	gms/kg/day
Non-hypermetabolic/Well nourished	1.0-1.3
Hypermetabolic and/or Protein-Calorie Malnutrition	1.2-1.5
Nitrogen retention disorders (liver, kidney)	0.5-1.0
Burn, >20% TBSA burn	2.0
Burn, <20% TBSA burn	1.5
High dose steroids	1.5
Hemodialysis (maintenance)	1.1-1.2
Hemodialysis (undernourished)	1.2-1.4
Peritoneal Dialysis (maintenance)	1.2-1.5
Peritoneal Dialysis (undernourished)	1.5-1.6

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.

Nutritional Status and Mortality in the Critically Ill*

Kris M. Mogensen, MS, RD, LDN, CNSC[1]; Malcolm K. Robinson, MD[2]; Jonathan D. Casey, MD[3]; Nicole S. Gunasekera, BA[4]; Takuhiro Moromizato, MD[5]; James D. Rawn, MD[2]; Kenneth B. Christopher, MD[6]

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

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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B2. We suggest the use of EN over PN in critically ill patients who require nutrition support therapy.

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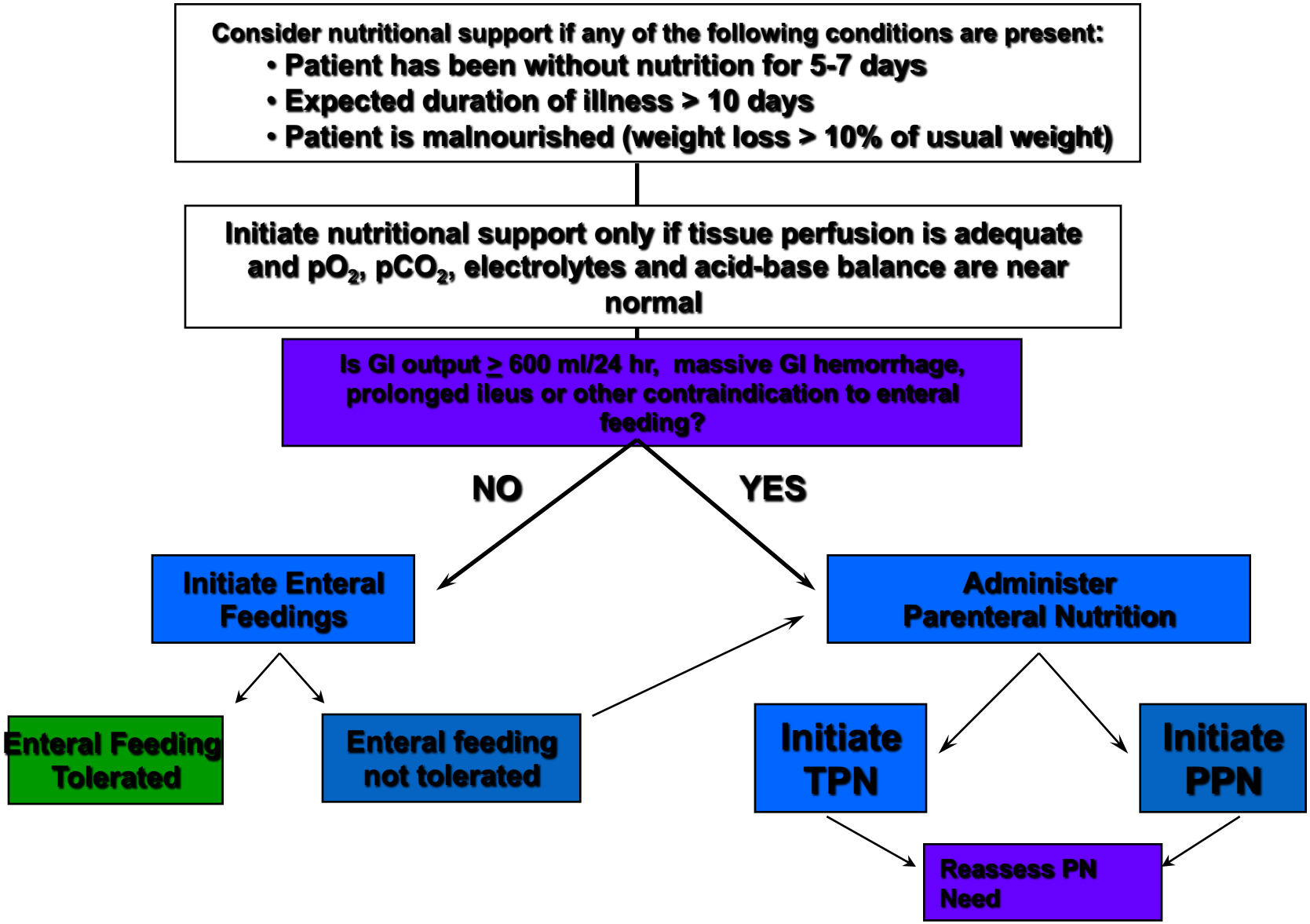
Determining Route of Feeding



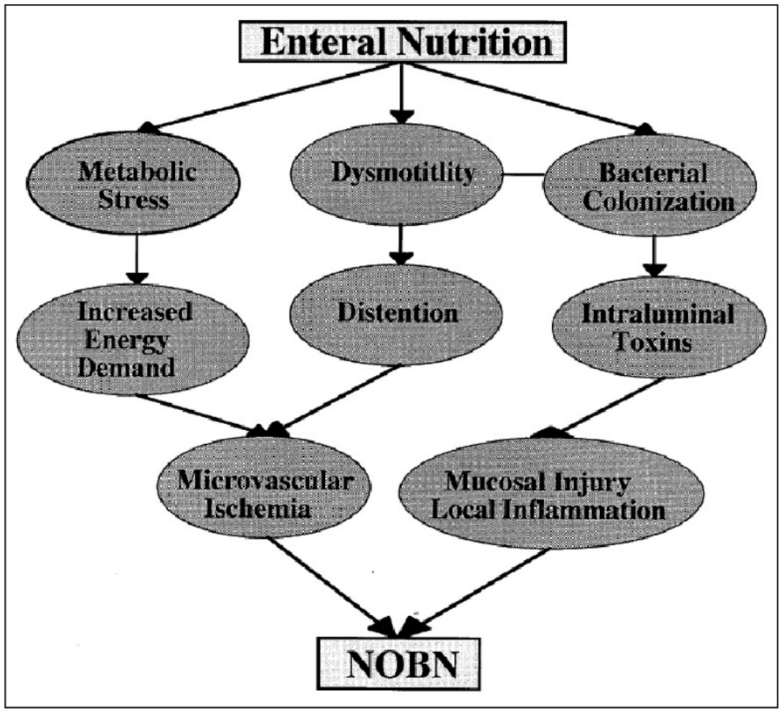


Figure 1. Non-occlusive bowel necrosis may result when enteral feeding leads to microvascular ischemia, mucosal injury, or local inflammation. Feeding the gut may cause some metabolic stress, dysmotility, and/or bacterial colonization that drive the aforementioned processes (13). Reproduced with permission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

Think Twice About EN if:

Epinephrine > 5 mcg/min
Norepinephrine > 5 mcg/min
Dopamine > 10 mcg/kg/min
Vasopressin > 0.04 units/minute
Milrinone > 0.375 mcg/kg/min

Suggested doses from "Enteral Feeding and Vasoactive Agents: Suggested Guideline for Clinicians." Nutrition Issues in Gastroenterology, Series #78

ASPEN Guidelines

Is EN safe during periods of hemodynamic instability in adult critically ill patients?

- **"Based on 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/re-initiation of EN may be considered with caution in patients undergoing withdrawal of vasopressor support."**

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 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.

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:

Specialized nutrition support is not indicated for well-nourished hospitalized patients who are expected to resume normal volitional intake within 7-10 days. However, patients who present to the hospital malnourished or are not expected to take adequate po for an extended period should be considered for immediate initiation of EN or PN. EN, unless contra-indicated, is the preferred over TPN for nutrition support. EN should be considered even in patients who are on low dose pressors if they are fully resuscitated and hemodynamically stable. TPN does not exacerbate bacteremia unless it is being infused via an infected catheter.

Tube Feeding Complications

Tube Related

Perforation

Bleeding

Malposition/Migration

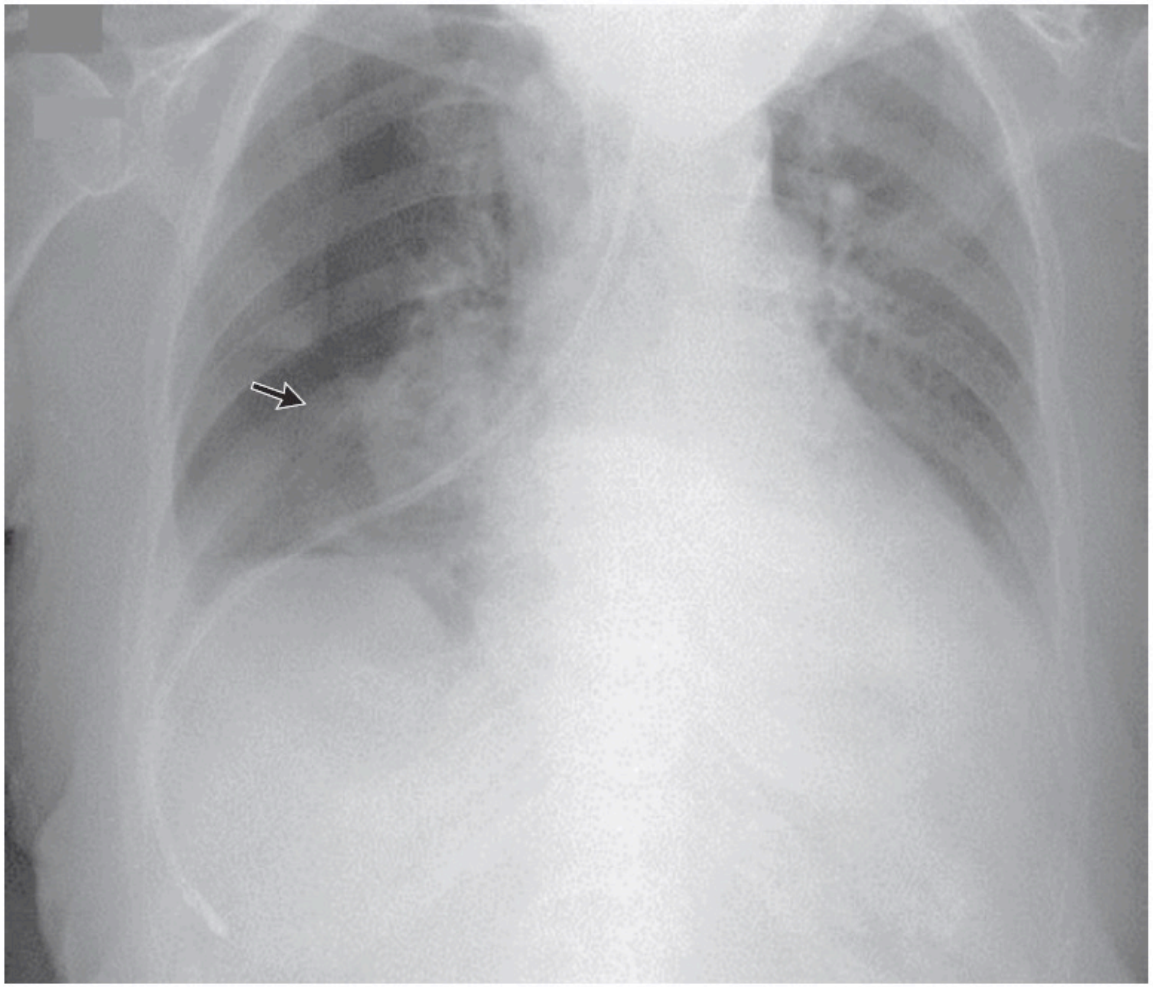
Obstruction

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.

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D4d. Based on expert consensus, we suggest that nursing directives to reduce risk of aspiration and VAP be employed. In all intubated ICU patients receiving EN, the head of the bed should be elevated 30°–45° and use of chlorhexidine mouthwash twice a day should be considered.

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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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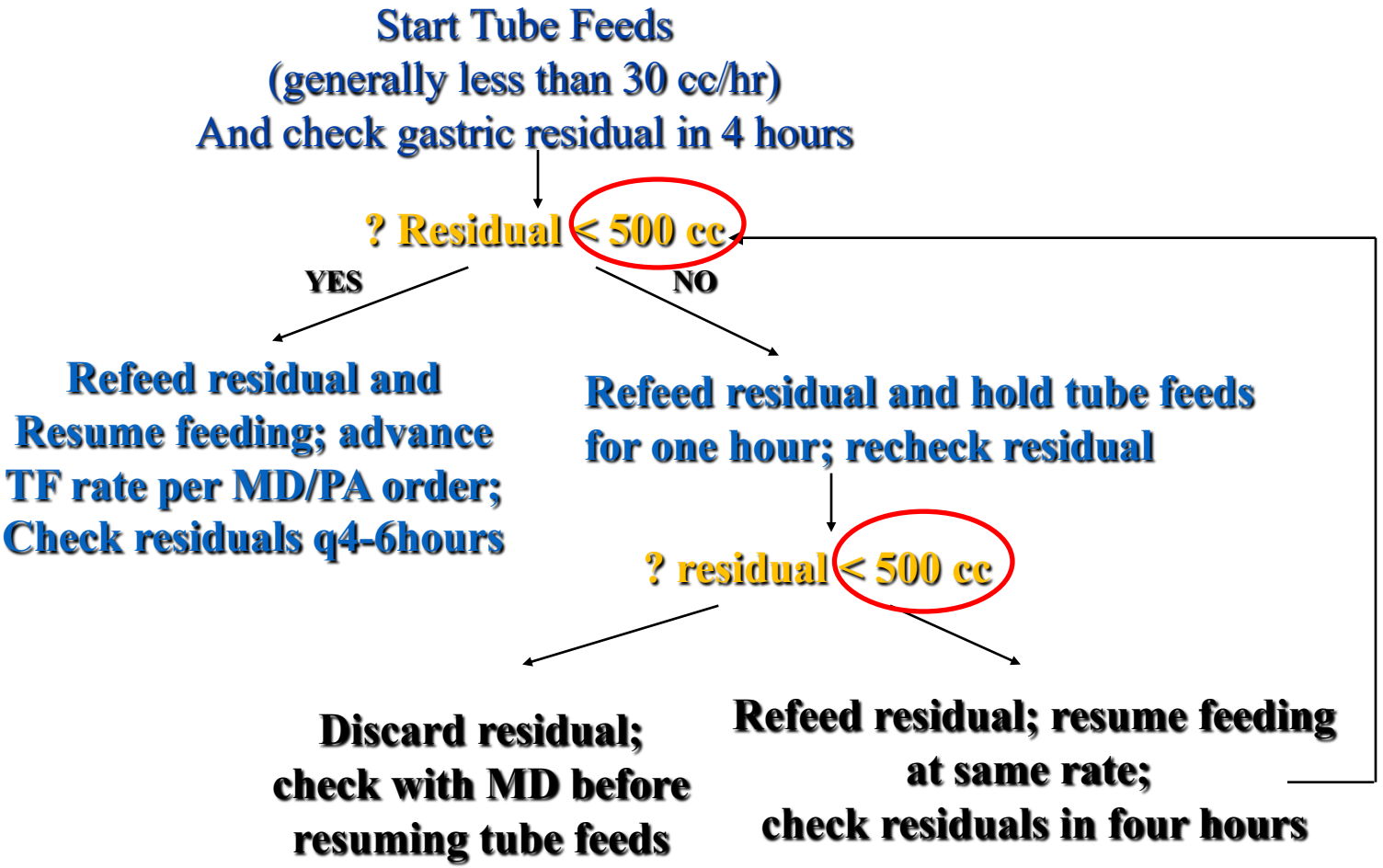
Gastric Residual Protocol



Tube feeds: Summary

- **Despite possibility of life-threatening cx's with TF's, the risk of such serious complications is relatively low.**
- **TF's, especially when administered "early," are associated with improved outcomes.**
- **In malnourished patients who can not tolerate TF's, however, TPN is better than prolonged starvation.**

CASE THREE

A 58 y.o woman is admitted to the ICU with a massive GI bleed. EGD controlled a visible bleeding vessel with a clip in the base of a duodenal ulcer. Prior to admission she had not eaten for 6 weeks due to pain chronic abdominal pain related to Crohn's, and she is now 85 % of her usual body weight. Regarding her nutrition:

A. Consider starting TPN immediately.
B. Specialized nutrition support is not indicated.
C. EN should be started immediately via naso-jejunal tube.
D. Her daily caloric needs can be determined by her REE x disease stress factor x activity factor.
E. Her daily caloric needs can be determined by her BMR x disease stress factor.

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.)

G3. We recommend that, in patients at either low or high nutrition risk, use of supplemental PN be considered after 7–10 days if unable to meet >60% of energy and protein requirements by the enteral route alone. Initiating supplemental PN prior to this 7- to 10-day period in critically ill patients on some EN does not improve outcomes and may be detrimental to the patient.

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Initiating TPN

Establish appropriate and dedicated venous access.

Guidelines for Infusion of Dextrose via Various Intravenous Catheters

Catheter	Dextrose
Subclavian; Jugular; PICC (tip in SVC)	≤30%
Femoral	≤15%
Peripheral (non-burn pt)	≤5%
Peripheral (burn pt)	≤10%
Multi-use (previously or presently used)	≤10%
Pulmonary Artery/Introducer Sheath*	No TPN
Arterial	No TPN

** TPN can be infused via Swan-Ganz catheters that have a extra lumen for SVC infusions dedicated for TPN use only.*

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.

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

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Placement of a naso-enteric tube is risky given the duodenal ulcer with bleeding vessel. In addition, the patient is moderately malnourished, and unlikely to return to adequate po intake given her chronic abdominal pain. Initiation of TPN should be immediately considered until adequate enteral feeding is assured. REE is measured in patients with a metabolic cart only needs to be multiplied by an activity factor to determine daily caloric needs. BMR which can be estimated by one of several formulas needs to be multiplied by a disease state stress and activity factors to determine daily caloric needs.

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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