Nutrition Care Manual

CRITICAL ILLNESS

OVERVIEW

Nutrition support, the provision of nutritional substrate via feeding tubes or intravenous catheters, is recognized as an important component in the overall care of critically ill patients (Doley, 2017; McClave, 2016; Cerra, 1997; Marik, 2001). Evidence continues to accumulate that properly applied nutrition support can reduce the risk of complications in this patient population, such as decreased length of stay and disease severity and decreased risk for malnutrition (McClave, 2016; Dhaliwal, 2015). Appropriate nutrition support early in the critically ill period has been shown to modulate the inflammatory response, maintain immune function, and prevent skeletal muscle catabolism (McClave, 2016), as well as prevent adverse structural and functional alterations in the mucosal barrier and enhance visceral blood flow (Martindale, 2017).

Most guidelines recommend the initiation of enteral nutrition in the critically ill within 24 to 48 hours of admission to the critical care unit. Provision of early enteral feeding is associated with decreased gut permeability and attenuation of the inflammatory cytokines (EAL, 2012; McClave, 2016; CCCPGC, 2015). During critical illness, the inflammatory response assists the body in recovery. Under proper conditions, the following is true of inflammatory response

- It is short-lived and well-coordinated
- It augments organ function
- It induces function of the cellular immune system
- It mobilizes nutritional substrate from muscle and fat tissue
- It utilizes these substrates to produce substances to support all the other functions

An excessive, prolonged, or dysregulated inflammatory response can lead to endothelial damage and organ failure, immune suppression, metabolic abnormalities, and erosion of body cell mass.

Critically ill patients are at risk for malnutrition or nutrition-related complications because hypermetabolism and the catabolic state often produced by the inflammatory response to illness can rapidly deplete protein stores and delay initiation of nutrient intake. Alterations in metabolism caused by catabolic hormone circulation impair nutrient utilization, and impaired nutrient utilization does not subside even with adequate nutrition support. Compromised nutritional status can contribute to longer hospital stays, poor wound healing, compromised immune function, and organ dysfunction (JeVenn, 2017; McClave, 2016; Mueller, 2011).

PRACTICE-RELATED GUIDELINES

Refer to the following clinical practice guidelines for additional, more explicit information:

The Academy of Nutrition and Dietetics Evidence Analysis Library published Critical Illness and Nutrition Support Guidelines in 2012. These guidelines are available here.

The European Society for Parenteral and Enteral Nutrition publishes guidelines on clinical nutrition in the intensive care unit every 9 years. The 2019 guidelines are available here.

The American Society for Parenteral and Enteral Nutrition publishes Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Adult Critically Ill Patient every 5-7 years. The 2016 guidelines are published here.

The American Society for Parenteral and Enteral Nutrition published Nutrition in Clinical Practice-Clinical Guide for the Use of Metabolic Carts in 2015. Subscription required; abstract is accessible here.

Canadian Clinical Practice Guidelines for Critical Care Nutrition were updated in 2015. There are 12 documents in these guidelines, which are accessible here.

NUTRITION ASSESSMENT

The purpose of nutrition assessment is to obtain, verify, and interpret data needed to identify nutrition-related problems, their causes, and significance. It is an ongoing, nonlinear and dynamic process that involves data collection and continual analysis of the patient/client's status compared to specified criteria.

Food/Nutrition-Related History

Information about food and nutrient intake—which can be obtained from family members or caregivers if the patient may not be able to provide it—is used to evaluate pre-illness nutritional status. It is important to obtain information about previous food and nutrient administration, including previous diets and/or food modifications, eating environment, enteral and parenteral nutrition administration, and fasting. Restricted or modified diets may alter the patient's macronutrient and micronutrient intake. Documenting macronutrient and micronutrient status helps to ensure adequate provision of potentially inadequate or deficient nutrients when nutrition support is initiated (JeVenn, 2017). Ascertain previous dietary habits and the effect on nutritional status prior to critical illness and, if the patient has any food allergies or intolerances, adjust nutrition support as needed.

Determine factors affecting access to food and food/nutrition-related supplies, including factors that affect intake and availability of a sufficient quantity of safe, healthful food and water, to determine the impact on food and beverage intake prior to critical illness.

Obtaining information about prior physical activity and function, which includes physical activity and cognitive and physical ability to engage in specific tasks, is important to ascertain if the patient was physically able to perform nutrition-related activities of daily living such as preparing meals or self-feeding prior to critical illness.

The General Nutrition Assessment section contains a comprehensive resource of all food/nutrition-related history parameters.

Anthropometric Measurements

Standard anthropometric measurements such as height, weight, and weight changes need to be evaluated carefully. Body weight of intensive care unit (ICU) patients often reflects fluid resuscitation or fluid retention. It is important to monitor fluid balance, since 1 L of fluid is equivalent to 1 kg of body weight (Martindale, 2017; Evans, 2017). Fluid retention may mask weight loss and could make it appear like a patient is maintaining weight at or above usual body weight at admission. Evaluation of weight changes before admission or before ICU stay—including weight history provided by patient or by family as needed—is often more meaningful than changes in weight of critically ill patients. Actual weight may be estimated utilizing information from the family if pre-resuscitation or presurgery weight is not available. If a previous weight history cannot be obtained, fluid intake and output can be tracked and subtracted from current weight (1 L of water = 1 kg).

A patient's physical activity and function assists in estimating current lean vs fat mass, which is important when assessing body composition and estimating energy and protein needs.

Anthropometric measurements that should be documented for all patients are available in the General Nutrition Assessment section.

Biochemical Data, Medical Tests, and Procedures

Biochemical data are not always transparent, because factors other than nutrition contribute to the measurements. Using clinical discernment and evaluating variables that affect these measurements is crucial when interpreting these data.

Use of ultrasound or computed tomography (CT) has been considered to evaluate body composition (JeVenn, 2017). Ultrasound results are affected by technical errors and edema. CT is more expensive, exposes the patient to radiation, and requires software to interpret data.

Resting Metabolic Rate, Measured

Indirect calorimetry (IC) is considered the gold standard for determining resting metabolic rate (RMR) in critically ill patients. The Academy of Nutrition and Dietetics Evidence Analysis Library (EAL) Critical Illness Guidelines, ASPEN/SCCM Critical Care Nutrition Guidelines, and ESPEN Guideline on Clinical Nutrition in the Intensive Care Unit identify IC as the most accurate and desirable method for determining metabolic rate. Note, however, that these EAL guidelines also acknowledge that limitations related to time, labor, equipment cost, and patient conditions may affect use of IC (EAL, 2012; McClave, 2016; Singer, 2018). Furthermore, there are no data to suggest that precise knowledge of a patient's metabolic rate does or does not influence outcome. For all these reasons, IC is often not performed on hospitalized patients and energy needs are estimated by one of many predictive equations (Wooley, 2017).

Laboratory Data

Electrolytes, renal profiles, blood glucose, and acid-base balance laboratory values are necessary to assess fluid status, renal function, adequacy of glucose control, and need for supplementation or restriction of electrolytes.

Laboratory Value	Normal Range
Blood urea nitrogen	7-23 mg/dL
Creatinine	0.6-1.5 mg/dL
Glucose, fasting	<99 mg/dL
Cations	
Sodium	136-145 mEq/L
Potassium	3.5-5 mEq/L
Calcium, ionized	4.5-5.5 mEq/L (9-11 mg/dl)
Magnesium	1.5-2.5 mEq/L (1.8-3 mg/dl)
Anions	
Chloride	96-106 mEq/L
Venous bicarbonate	21-28 mEq/L
Phosphorus	2.4-4.5 mg/dl (1.9-2.85 mEq/L as HPO_4^{2-})

Reference ranges may vary slightly by institution or by condition (eg, sodium goals may differ among patients requiring neurocritical care)

Serum albumin, prealbumin, retinol-binding protein, and transferrin are negative acute-phase proteins that often appear low during critical illness due to hepatic reprioritization and fluid shifts. C-reactive protein, a positive acute-phase protein, becomes elevated during critical illness due to stress and inflammation. These proteins may be prognostic indicators of degree of inflammation but are not indicators of nutritional status in the critically ill and should not be used to determine the patient's protein needs (McClave, 2016; JeVenn, 2017; Martindale, 2017; Evans, 2017).

When assessing the protein intake, the most useful (though still limited) laboratory test in clinical practice may be nitrogen balance, as this test provides information regarding whether protein intake matches catabolic demand. The 2013 obesity guidelines of the American Society for Parenteral and Enteral Nutrition support nitrogen balance studies as an effective procedure for determining goal protein needs (Choban, 2013).

Important limitations that may affect accuracy of the nitrogen balance test include renal failure, incomplete urine collection, diuretic use, difficulty estimating protein delivery among patients with oral intake and/or limited intake data, and quantification of protein losses (eg, drains, wounds, dialysate, ostomy or fistula output). Protein loss quantification can be difficult and may be of limited utility because a positive nitrogen balance essentially is unachievable until the catabolic phase has resolved (Young, 2017; Evans, 2017)

A markedly negative balance is likely an indication that protein intake should be increased, whereas a markedly positive balance is an indication that an error has been made in the measured or estimated nitrogen output. The nitrogen equilibrium target is –4-5 g/day to +4-5 g/day) (Dickerson, 2016).

Hyperglycemia, renal function, hepatic function, and acid-base status can be assessed with standard laboratory data. As with many other measurements in critical care patients, serial values are more useful than single values because trends can be detected. For example, if blood urea nitogen (BUN) and creatinine gradually increase, despite adequate kidney function and/or renal replacement therapy, nutritional intake should be evaluated, and nutrition prescription adjusted as needed. If serum glucose levels fluctuate, evaluation should determine if it is related to nutrition support provision and adjustments made as needed. Serum electrolyte trends may help identify refeeding syndrome, for example, and whether appropriate electrolyte replacement is taking place. A review of serum electrolytes, BUN, and creatinine for abnormalities may help identify underhydration or overhydration status or whether excess electrolyte replacement has occurred. BUN may also be low in the setting of markedly reduced body cell mass; BUN and creatinine can be elevated, and electrolyte levels abnormal, in renal failure. Hyperglycemia may be a nonspecific indicator of the inflammatory response (JeVenn, 2017).

Nutrition-Focused Physical Findings

Over time, physical characteristics of critically ill patients will change. Extended bed rest and the catabolic effect of inflammatory response on skeletal muscle will generally cause tissue wasting. Fluid accumulation, if present, may mask the extent of the tissue wasting.

Systemic inflammatory response syndrome (SIRS) is nonspecific and common in critical care patients, but its presence with a source of infection constitutes sepsis, which can progress to severe sepsis and septic shock. Vital signs can be used in determining whether systemic inflammatory response is present (Martindale, 2017; Winkler, 2017). See table below. Understanding SIRS can help to determine which mode of nutrition support is indicated.

Definition of the Inflammatory or Septic Response

Septic Response	Definition
Systemic inflammatory response syndrome (SIRS)[a]	Site of infection established, and at least 2 criteria met: Body temperature > 100.4°F or < 96.8°F Heart rate > 90 beats/minute (tachycardia) Respiratory rate > 20 beats/minute (tachypnea) PaCO2 of < 32 mm Hg (hyperventilation) White blood cell count > 12,000/mm3 or < 4000/mm^3 Bandemia—the presence of more than 10% bands (immature neutrophils) in the absence of chemotherapy-induced neutropenia and leukopenia
Sepsis	Source of infection + SIRS
Severe sepsis	Sepsis + at least 1 organ dysfunction
Septic shock	Sepsis + hemodynamic instability

[a]Not yet septic.
Source: Martindale , 2017; Winkler, 2017.

The following table outlines pertinent nutrition-focused physical findings for adults during critical illness.

Obtaining nutrition-focused physical data in critically ill patients can be challenging. Ask bedside caregivers/nursing staff for assistance to ensure accurate information is obtained and documented.

Physical Findings	Clinical Significance	Notes
Adipose		
Loss of subcutaneous fat (orbital, triceps, fat overlying ribs	Mild loss can be sign of moderate malnutrition Moderate loss can be sign of severe malnutrition in the context of acute injury or illness Severe loss can be a sign of severe malnutrition in the context of chronic illness or social or environmental circumstances	
Bones		
Bowlegs Rickets Scoliosis Acromion abnormal prominence Clavicle abnormal prominence Rib abnormal prominence Scapula abnormal prominence Iliac crest abnormal prominence Patella abnormal prominence	Possible inadequate vitamin D or calcium intake, or deficiency Possible loss of muscle tissue Possible loss of muscle tissue Possible loss of subcutaneous fat tissue Possible loss of muscle tissue Possible loss of subcutaneous fat tissue Possible loss of muscle tissue	Mild muscle wasting can indicate moderate malnutrition Moderate to severe muscle wasting can indicate severe malnutrition
Cardiovascular-pulmonary system		
Bradycardia Dyspnea	Possible anorexia nervosa, hypothyroidism Possible fluid overload	Evaluate weight status, weight history
Digestive system		
Abdominal bloating Abdominal distension Absence of bowel sounds Ascites Constipation Diarrhea Hyperactive bowel sounds Hypoactive bowel sounds	Possible fluid retention Possible gastrointestinal dysfunction Possible gastrointestinal ileus Fluid retention Possible decreased motility Possible increased GI function Possible gastrointestinal obstruction	Evaluate weight status, intake tolerance Evaluate intake and onput/enteral nutrition (EN) tolerance Evaluate bowel function Evaluate imaging if available Absence of bowel sounds is not a contraindication to EN initiation Evaluate weight status, intake status Evaluate intake tolerance, med regimen Evaluate electrolyte status, infectious source, medications (eg, sorbitol, antibiotics, laxatives) Evaluate npo time frame Evaluate ability for oral or EN intake

	Possible gastrointestinal dysfunction	Monitor tolerance to oral/EN intake
Edema		
Anasarca (generalized) Edema: +1 pitting, +2 pitting, +3 pitting, +4 pitting Ankle, calf, thigh, sacral Scrotal or vulvar edema	Mild generalized or local edema in the areas listed can be a sign of moderate malnutrition; Moderate to severe generalized or local edema in the areas listed can be a sign of severe malnutrition	Edema can mask weight loss or cause weight gain Edema can be an indicator of possible organ dysfunction (eg, kidney, liver, heart)
Extremities		
Amputated extremity	Decreased calorie and protein needs	Adjust estimated energy and protein needs accordingly
Eyes		
Abnormal vision Night blindness Angular blepharitis Bitot's spots Scleral pallor Xerophtalmia (conjunctival xerosis) Keratomalacia (Corneal xerosis)	 Vitamin A deficiency Riboflavin or niacin deficiency Vitamin A deficiency Iron, folate, or B12 deficiency	Deficiencies are likely related to long-term, inadequate intake rather than acute onset during critical illness
Genitourinary system		
Amenorrhea Menorrhagia Anuria, oliguria polyuria	Possible eating disorder Possible iron deficiency Renal dysfunction Possible hyperglycemia	Evaluate weight status, weight history Evaluate iron status Evaluate renal function Evaluate blood glucose levels
Hair		
Dry hair; hair lacks luster; increased loss of hair Easily pluckable hair	Protein, iron, zinc, or essentially fatty acid deficiency Protein or micronutrient deficiency	
Head		
Altered olfactory sense Anosmia Hyposmia	May cause decreased sense of taste Possible zinc deficiency	

Nasal mucosa dry	Possible dehydration	Evaluate hydration status
Hand and nails		
Koilonychia (pale fingernails) Nail changes: (Lackluster, dull nails, Beau's line, white banding) (Poor blanching) Flaking of nails	Iron deficiency Protein deficiency Vitamin A or C deficiency Magnesium or selenium deficiency	
Mouth		
Cracked lips Angular stomatitis Cheilosis Mucosa Pale gums Dysgeusia, hypogeusia Dry mucus membranes Gums Spongy, bleeding, receding Parotid swelling	Riboflavin, niacin, and/or pyridoxine deficiency Riboflavin or niacin deficiency Iron, B12, or folate deficiency Possible zinc deficiency Dehydration Vitamin C deficiency Protein deficiency or bulimia	 Evaluate zinc status Evaluate hydration status
Muscles		
Muscle atrophy: temple region (temporalis), Clavicles (pectoral and deltoid), shoulders (deltoid), interosseous hand, scapula (latissimus dorsi, trapezius, deltoid), thigh (quadriceps), calf (gastrocnemius)	Mild loss of muscle mass in any two areas can be a sign of moderate malnutrition Moderate to severe loss of muscle mass in any two areas can be a sign of severe malnutrition	
Skin		

Pale complexion Dermatitis Hyperpigmentation Petechiae, ecchymosis Impaired wound healing, pressure injuries Moisture, turgor Decreased skin turgor Scaling, dry skin	Iron, folate, or B12 deficiency Essential fatty acid, zinc Niacin or tryptophan deficiency Vitamin C or K deficiency Protein, zinc, Vitamin A, or Vitamin C deficiency Increased fluid requirements Vitamin A or essential fatty acid deficiency	Wound healing is multifactorial but may be affected by deficiency of the nutrients listed
Throat and swallowing		
Dysphagia	Inability to safely swallow if oral intake	Consider speech pathology consult to evaluate swallowing
Tongue		
Magenta tongue Beefy red tongue Lesions Atrophy of tongue papillae	Riboflavin deficiency Niacin, folate, riboflavin, iron deficiency Folate, niacin, iron, riboflavin, B12 deficiency	
Vital signs		
Respiratory rate Temperature	Energy expenditure	Temperature and respiratory rate affect energy needs If the patient has unstable vital signs, it may be indicated to delay EN initiation

Source: White, 2012; Malone, 2013.

See the General Nutrition-Focused Physical Findings section for all nutrition-focused physical assessment parameters.

Client History

The assessment of patient/client history relates personal, medical, family, and social history, both current and in the past, which will vary by patient/client.

Client history is useful for anticipating risk of complications, metabolic needs, possible restrictions on fluid and electrolyte intake, and feeding routes.

Patient/Client or Family Nutrition-Oriented Medical/Health History

Identify any medical history that could affect nutritional status or nutrition support: cardiovascular, endocrine, gastrointestinal, oncological, immune, integumentary, neurologic, respiratory conditions.

Identify any medical or surgical treatments that could affect nutritional status or ability to provide nutrition support: history of gastric bypass surgery or other gastrointestinal resection or surgery, short bowel syndrome, chemotherapy, radiation therapy.

Seek information regarding end-of-life decisions that may limit the ability to provide nutrition support (ie, documented patient wish for no nutrition support to prolong life).

Treatments/Therapy

All forms of organ support (mechanical ventilators, dialysis methods, inotropes, and fluids), and all access devices to the gastrointestinal tract (gastric tubes, enteric tubes) and circulatory system (peripheral and central catheters) related to the patient should be documented.

COMPARATIVE STANDARDS

Estimated Energy Needs

If predictive equations are needed due to inaccessibility to indirect calorimetry, current evidence suggests that the Penn State equations are accurate in nonobese and obese critically ill patients more often than other equations (Frankenfield, 2009; Frankenfield, 2011; EAL, 2012).

In 2009, the Penn State equation was demonstrated to be the best predictive equation of three, with an overall accuracy rate of 67% compared with 46% for Ireton-Jones and 54% for Swinamer (Frankenfield, 2009). Predicting metabolic rates in patients who are age 60 years or older and have a body mass index (BMI) of 30 or higher is particularly difficult.

Targets for energy and protein intake often are not met in critically ill patients (Heyland, 2015; Singer, 2018). Measurements of metabolic rate and nitrogen balance are often not conducted at initial assessment nor follow-up, so needs are based on probability rather than certainty. Furthermore, there is controversy regarding whether it is desirable to meet 100% of nutrient demand (especially energy) in early-stage critically ill patients (McClave, 2016; Dhaliwal, 2015; Singer, 2018). SCCM and ASPEN recommend providing 65% to 70% of IC measured or using the guidelines in the Predictive Equations table below, along with recommendations for protein (McClave, 2016).

Predictive Equations for Critically Ill Patients

Condition	Equation	Recommended by
Nonobese, mechanically ventilated	PSU 2003b RMR = Mifflin (0.96) + VE (31) + Tmax (167) – 6,212	Academy EAL
Obese, mechanically ventilated, younger than 60 years	PSU 2003b RMR = Mifflin (0.96) + VE (31) + Tmax (167) –	Academy EAL

Predictive Equations for Critically Ill Patients

Condition	Equation	Recommended by
	6,212	
Obese, mechanically ventilated, older than 60 years	PSU 2010 RMR = Mifflin (0.71) + VE (64) + Tmax (85) – 3,085	Academy EAL
Obese	11-14 kcal/kg actual weight 22-25 kcal/kg ideal body weight	ASPEN/SCCM

* Note: For the Mifflin-St Jeor equation, actual body weight is used.

Abbreviations: EAL, Evidence Analysis Library; PSU, Penn State University; RMR, resting metabolic rate; VE, minute ventilation in L/min; Tmax, maximum daily temperature in Celsius; ASPEN/SCCM, American Society for Parenteral and Enteral Nutrition/Society for Critical Care Medicine.

Mifflin-St Jeor equation used in Penn State University: RMR males = 10 × weight (kg) + 6.25 × height (cm) – 5 × age (y) + 5; RMR females = 10 × weight (kg) + 6.25 × height (cm) - 5 × age (y) – 161

Sources: Mifflin, 1990; EAL, 2012; McClave, 2016.

See the NCM Calculators section for more information about calculating estimated energy needs.

Macronutrient Needs

Estimated Protein Needs

Protein needs in critically ill patients tend to be elevated, often significantly. Recommendations generally range from 1.2 g/kg body weight to 2.0 g/kg body weight but could be higher (McClave, 2016; Evans, 2017). For example, in patients requiring continuous renal replacement therapy, the recommendation for protein intake ranges from 1.5 g/kg/day to 2.0 g/kg/day; this intake potentially will need to increase up to 2.5 g/kg/day due to the breakdown of muscle tissue during catabolism and loss of amino acids via dialysate during continuous renal replacement therapy (McClave, 2016; Sarav, 2017).

In obese critically ill adults, hypocaloric, high-protein feedings may be appropriate. Very limited research in patients primarily receiving enteral nutrition (EN) has shown that a hypocaloric, high-protein feeding (< 20 kcal/kg adjusted body weight and 2 g protein/kg ideal body weight) promoted shorter intensive care unit stays; however, total length of hospital stay did not differ. Nitrogen balance was not adversely affected. The effect of this feeding regimen on infectious complications, days on mechanical ventilation, mortality, and cost of care is unsubstantiated (EAL, 2012).

According to the American Society for Parenteral and Enteral Nutrition Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient published in 2016, it is recommended to provide hypocaloric, high-protein nutrition support to obese critically ill patients (McClave, 2016). Evidence supports improved or similar outcomes comparing hypocaloric high-protein feeding with eucaloric high-protein feeding (Choban, 2013; McClave, 2016). In the European Society for Parenteral and Enteral Nutrition intensive care unit guidelines (Singer, 2018), it is recommended to use urinary urea nitrogen studies or an adjusted body weight to determine protein needs for obese patients, taking into account age, previous activity level, and body composition of the patient.

How to estimate protein needs in critically ill patients (McClave, 2016; Evans, 2017; Martindale, 2017; Choban, 2013):

- 20% to 25% of total energy for stressed patients, including those with burns
- 1.2 g/kg/day to 2.0 g/kg/day actual body weight if BMI is < 30 (may be higher in burn/trauma patients)

- 2.5 g/kg/day in early postop burn patients, up to 4 g/kg/day during flow period
- 2.0 g/kg/day to 2.5 g/kg/day for patients receiving continuous renal replacement therapy
- 2.0 g/kg/day ideal body weight if BMI is 30 to 40 and hypocaloric feeding is used
- 2.5 g/kg/day ideal body weight if BMI is > 40 and hypocaloric is feeding used

Fluid Needs

Fluid needs in the critically ill patient will often be influenced by the physiologic state. Variables for estimating fluid needs include the following:

- Need for volume resuscitation
- Extent of endothelial injury and capillary leak
- Acute and preexisting disorders of cardiac and renal function

Fluids will be administered to achieve a certain physiologic endpoint (eg, a target mean arterial pressure, central venous pressure, or cardiac output) rather than a specific target volume. The standard methods of fluid calculation should not be strictly applied in many critically ill patients.

Example: A patient weighing 70 kg has a calculated fluid need of 2,100 mL/day (30 mL/kg) but is hypovolemic, requiring inotropes and fluid boluses to maintain hemodynamic stability; thus, a total fluid intake greater than 3,000 mL is appropriate, even though the patient's body weight might be increasing from fluid accumulation in interstitial tissues. This example does not indicate that all 3,000 mL should come from the nutrition support received by the patient, but only that the typical fluid calculations would not apply in this situation.

Micronutrient Needs

The belief that micronutrient needs are elevated during critical illness is based on the premise that micronutrients are needed to meet the increased metabolic demands associated with injury (Evans, 2017).

For micronutrients, aim for patients to meet at least the Dietary Reference Intakes (DRI) during critical illness. See DRIs for general nutrition recommendations for healthy people.

NUTRITION DIAGNOSIS

Common nutrition problems in this population include increased energy expenditure, inadequate oral intake, increased nutrient needs, altered nutrition-related laboratory values, and impaired nutrient utilization. The metabolic response to injury and critical illness can increase energy and protein needs in critically ill individuals beyond their usual energy needs. Critical illness inhibits adequate oral intake, often because patients are mechanically ventilated and unable to consume intake orally. These individuals are at risk of organ and organ system dysfunction, which causes derangements in laboratory values related to organ function and puts them at risk for impaired nutrient utilization.

Sample PES (problem, etiology, signs and symptoms) or nutrition diagnostic statement(s):

- Increased energy expenditure related to increased physiologic demand due to metabolic response to stress as evidenced by measured resting metabolic rate greater than estimated energy needs.
- Inadequate oral intake related to sedation induced inability to consume sufficient energy as evidenced by an order for nil per os, or nothing by mouth, for 3 days.
- Moderate acute disease or injury related malnutrition related to physiologic response to pneumonia as evidenced by mild muscle loss of the temporalis, clavicle, and deltoid/shoulder regions and estimated energy intake < 75% of estimated needs for > 7 days.

NUTRITION INTERVENTION

The goal of nutrition support in critical illness is to improve outcomes—mainly, infection rate, days spent on the ventilator, and days spent in the critical care unit (Dhaliwal, 2015; McClave, 2016; Singer, 2018). This goal is accomplished by the following:

- Initiating nutrition support—enterally whenever possible—early and in a safe manner
- Avoiding overfeeding, possibly by allowing mild underfeeding (especially in parenteral nutrition)
- Tightly controlling blood glucose, 140 mg/dL to 180 mg/dL (Walker, 2017)
- When appropriate, providing immunonutrients

A secondary goal is to minimize the catabolic loss of body protein, thereby minimizing the debility that can result from loss of muscle mass.

Enteral Nutrition Amount That Must Be Fed

Insufficient data exist to determine whether the goal level of energy intake must be achieved to maximize the outcome benefits of enteral feeding. Retrospective studies suggest that the magnitude of the cumulative energy deficit correlates with poor outcome; there is limited research suggesting that hypocalorically fed patients have shorter intensive care unit stays, although total length of stay did not differ (EAL, 2012). The Academy of Nutrition and Dietetics Evidence Analysis Library (EAL) Critical Illness Guidelines recommend that average intake actually delivered within the first week be greater than 60% of total energy need. Pushing an enteral feeding beyond the ability of the gastrointestinal tract to tolerate is known to be detrimental (EAL, 2012). If a patient is at high nutritional risk or malnourished, the American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines recommend that enteral nutrition should be advanced to goal within 24-48 hours, with a goal of >80% of estimated energy needs as the goal within 48-72 hours (McClave, 2016); European Society for Enteral and Parenteral Nutrition (ESPEN) guidelines state that enteral nutrition should be increased to 70% to 100% of resting energy expenditure within 48 hours (Singer, 2018). For obese individuals, an overall target for intake is 65% to 70% of target energy needs as measured by indirect calorimetry (McClave, 2016). Additional research is needed to help determine effects of hypocaloric, high-protein feeding, and permissive underfeeding.

Enteral Feeding Guidelines

Guidelines from ASPEN, the Academy of Nutrition and Dietetics (Academy), the Canadian Critical Care Practice Guidelines Committee (CCCPGC), and ESPEN suggest that some specialized feeding compositions (eg, fish oils, glutamine [not supported by the CCCPGC guidelines]) are indicated in certain patients (McClave, 2016; Academy EAL, 2012; CCCPGC, 2015; Singer, 2018). See enteral formula selection below.

CCCPGC, EAL, ASPEN/SCCM, and ESPEN have issued guidelines for enteral nutrition in critically ill patients.

Component of Enteral Nutrition	CCCPGC	EAL	ASPEN/SCCM	ESPEN
Type of enteral formula/protein	Whole protein (polymeric) should be considered	No recommendations	Use standard polymeric formula	No recommendations
Enteral nutrition (EN) supplemented with arginine	Not recommended	Carefully evaluate use	Consider for traumatic brain injury (TBI) and perioperative surgical intensive care unit (SICU) patients Use caution with sepsis	No recommendations
EN supplemented with fish oil, borage oil, and antioxidants	Recommended with acute respiratory distress syndrome, ALI, sepsis	Consider with acute respiratory distress syndrome and acute lung injury	Consider with TBI and peri-operative SICU patients; not recommended with severe acute respiratory distress syndrome and acute lung injury, or in medical intensive care unit (MICU)	Consider in ALI or acute respiratory distress syndrome patients
Enteral glutamine	Recommend in burn and trauma patients, do not use with shock and multi-organ failure	Not recommended, except consider with burns	Supplement not recommended; recommended for TBI and SICU perioperative patients; not recommended in MICU	Recommended in burn, trauma, and complicated wound healing patients only
Fiber	Routine use not recommended (insufficient data to support)	May use soluble fiber except when there is hemodynamic instability, severe dysmotility, and positive *Clostridium difficile* Soluble fiber recommended to prevent/manage diarrhea	Soluble fiber recommended for stable patient with diarrhea, avoid insoluble fiber if at risk for bowel ischemia or severe dysmotility	No recommendations
Gastric residual volumes (GRVs)	GRVs of 500 mL vs 250 mL are not associated with increased GI complications but are associated with significantly better	Suggest that EN should not be held for GRVs <500 mL in absence of other signs of intolerance	Suggest monitoring GRVs not be part of routine care for ICU EN patients If monitored, suggest	No recommendations

Component of Enteral Nutrition	CCCPGC	EAL	ASPEN/SCCM	ESPEN
Type of enteral formula/protein	Whole protein (polymeric) should be considered	No recommendations	Use standard polymeric formula	No recommendations
	nutrition delivery Not checking GRVs vs checking GRVs >250 mL threshold is associated with a significantly better energy delivery		that EN should not be held for GRVs <500 mL in absence of other signs of intolerance	

Sources: CCCPGC, 2015; McClave, 2016; Academy EAL, 2012; Singer, 2018.

Nutrition Intervention	Recommendations
Enteral nutrition	Initiate EN early within 24-hours to 48-hours of admission to ICU to attenuate the stress response and decrease muscle atrophy related to catabolism from the metabolic response. Early initiation of EN is associated with decreased gut permeability (Academy EAL, 2012; McClave, 2016; CCCPGC, 2015; Doley, 2017). The presence or absence of bowel sounds and/or flatus should not preclude the use of enteral nutrition (Singer, 2018; Doley, 2107; McClave, 2016).
Modify rate of enteral nutrition	Initiate regimen at between 10 mL/hour and 40 mL/hour (Doley, 2017). Initiate regimen at full strength, and advance 10 to 20 mL every 8 to 12 hours over the next 48 to 72 hours until the goal rate is achieved (Singer, 2018; McClave, 2016; Dhaliwal, 2015). Many hemodynamically stable critically ill patients can tolerate rapid EN advancement in 24 to 48 hours or may be able to tolerate starting at goal rate to help prevent calorie and protein deficits (Doley, 2017).
Modify route of enteral nutrition	Gastric access is often adequate, but in cases where the stomach is not functional and in certain high-risk groups (such as patients with severe torso and abdominal injury, severe head injury, major burns, major intra-abdominal surgery, previous aspiration, persistent gastric residual volumes of > 500 mL, require prolonged supine or prone positioning, or multiple surgeries), small bowel route is indicated (Martindale, 2017; Evans, 2017). Gastric access may be used if the stomach is functional, with conversion to duodenal or jejunal access if the patient presents with high aspiration risk or enteral feeding intolerance (Singer, 2018; McClave, 2016; CCCPGC, 2015). The CCCPGC recommends that the small bowel is the

	preferred location for tube placement in critical care units where small bowel access is logistically feasible. In critical care units where placement of small bowel tubes is more problematic, small bowel placement should be reserved for patients at high risk for aspiration (Singer, 2018; McClave, 2016, CCCPGC, 2015), or feeding intolerance (such as patients on inotropes, receiving continuous sedation or paralytics, and with proven gastric dysfunction) (Singer, 2018; Martindale, 2017; McClave, 2016; CCCPGC, 2015).
Modify rate, volume or schedule of enteral nutrition	Delivery of nutrients may be improved by adopting enteral feeding protocols (Singer, 2018; Doley, 2017; McClave, 2016; CCCPGC, 2015). As part of an enteral feeding protocol, volume-based feeding, which prescribes EN by goal volume per day instead of a goal rate, should be considered in hemodynamically stable patients. This type of regimen usually starts at goal rate, or advances to goal rate in 24-48 hours, and adjusts the rate as needed to meet a goal volume. It has been shown to improve nutrient delivery (Singer, 2018; Doley, 2017; McClave, 2016; Heyland, 2015.
Modify composition of enteral nutrition	There are no data indicating the optimal feeding formula in critical care. An effective formula may be high in protein (kilocalorie to nitrogen ratio of approximately 100:1); low in total fat with a significant component coming from medium-chain triglyceride (at least 25% of total fat); high in vitamins and minerals (greater than the Dietary Reference Intakes for healthy people, especially for antioxidants); and, if appropriate, containing soluble dietary fiber. The Academy Evidence Analysis Library issued limited recommendations regarding immune-modulating formulas, whereas the CCCPGC (Dhaliwal, 2015), ASPEN (McClave, 2016), and ESPEN (Singer, 2018) guidelines give a more favorable recommendation for these types of formulas (Singer, 2018; McClave, 2016; CCCPGC, 2015). Immune-enhanced formulas have been shown to decrease risk of infection rates and complications, length of stay, and mortality in critical care populations (Roberts, 2017). ASPEN guidelines recommend use in surgical ICU trauma and post-operative patients, but not in patients with severe sepsis or patients in medical ICU (McClave, 2016). CCCPGC guidelines do not recommend the use of immune enhancing formulas in critically ill patients, except in critically ill elective surgery patients, as they are associated with a significant reduction in infection rates in this population (Dhaliwal, 2015). ESPEN guidelines state that the use of enteral formulas containing fish/borage oil and antioxidants may be associated with reduced ICU length of stay and ventilator dependent days. Their use is also associated with reduced mortality in patients with acute lung injury, acute respiratory distress syndrome, or sepsis (Singer, 2018).

	For more information about use of specialized enteral formulas, please refer to the table above.
Modify concentration of enteral nutrition	Fluid needs in critical care patients can be markedly different (higher or lower) than those in healthy people and can change during the course of illness. In cases where restriction of fluid intake is indicated, a concentrated feeding formula should be used; however, this formula may not provide sufficient protein. Utilizing a protein modular may be required. If there is no need for fluid restriction, less-concentrated, high-protein formulas can be used. ASPEN guidelines recommend use of a fluid restricted enteral formula for patients with acute respiratory failure, especially if volume overload occurs (McClave, 2016).
Parenteral nutrition (PN)	CCCPGC and ESPEN guidelines emphatically state that all strategies for maximizing EN (such as postpyloric tubes and promotility agents) should be applied before PN is considered, and even then the safety and benefits of initiating therapy must be carefully weighed (Singer, 2018; CCCPGC, 2015). Use of PN in critically ill patients has been shown to increase infectious complications (Martindale, 2017) and costs when compared to EN (Academy EAL, 2012). In the case of malnourished patients where EN is not feasible, the ASPEN and CCCPGC guidelines recommend immediately starting PN (McClave, 2016; Dhaliwal, 2015). ASPEN guidelines also recommend consideration of PN if the patient is at high nutritional risk (McClave, 2016). ESPEN guidelines recommend initiation of PN within 3 to 7 days if EN or oral intake are not feasible (Singer, 2018).
Modify schedule of parenteral nutrition	The ASPEN guidelines set a time frame of 7 to 10 days in which to achieve intake goals by the enteral route before adding PN (McClave, 2016). CCCPGC's state that early supplemental PN may be associated with increased infectious complications, longer ICU and hospital length of stay, and increased mechanical ventilation time (Dhaliwal, 2015).
Modify composition of parenteral nutrition	McClave and colleagues recommended to hold soy-based lipid administration in the first week of PN administration, unless the patient is at risk of essential fatty acid deficiency; when that risk is present, administer 100 g in two divided doses (McClave, 2016). However, this recommendation is based on only one study from more than 20 years ago and hasn't been duplicated (Kumpf, 2017; McClave, 2016). Holding soy-based lipids may be associated with reduction in infections in critically ill

	patients and may decrease length of stay and mechanical ventilation in trauma patients (Dhaliwal, 2015). There is some evidence to support consideration of lipids that are not solely omega 6 fatty acid based (Singer, 2018; Kumpf, 2017; Patel, 2017; McClave, 2016; Dhaliwal, 2015).
Vitamin and mineral supplement therapy	There is some evidence that supports antioxidant supplementation in trauma and septic patients, but not enough to guide supplement dosing and duration (Singer, 2018; Martindale, 2017; McClave, 2016). Further research is needed to determine optimal dosing and duration of antioxidants, selenium, and zinc in critically ill populations. The Recommended Dietary Allowances for antioxidants and trace elements are recommended for all critically ill patients during hospitalization (Martindale, 2017).
Meals and snacks	Oral intake should be reestablished as soon as possible. However, safety of resuming the diet should first be assessed (eg, a swallowing evaluation should be conducted to determine that the patient does not have an aspiration risk). Tube feeding or parenteral nutrition also should not be discontinued until the patient's appetite and willingness to eat are sufficient to support needs; the threshold is often set at meeting 66% to 75% of needs by the oral route (Doley, 2017; Evans, 2017).

General information about Enteral Nutrition, Parenteral Nutrition, Complications of Nutrition Support, and Refeeding Syndrome is presented in the Nutrition Support Toolkit.

Adequacy of Nutrition Therapy

If providing enteral nutrition, usually a prescription of 1 L formula or greater provides the Dietary Reference Intakes (DRIs). Parenteral nutrition support meets the DRIs for most nutrients; however, iron is generally not added to parenteral nutrition solutions.

Nutrition Therapy Efficacy

Early enteral feeding is more efficacious than late enteral nutrition or parenteral nutrition in critically ill patients (Singer, 2018; McClave, 2016; Dhaliwal, 2015; EAL, 2012). Efficacy in this context refers to therapy that minimizes ventilator days and complications such as infection. However, it is common for the intake of all nutrients to fall below target when delivered enterally (Heyland, 2015). Delivery of nutrients may be improved by adopting enteral feeding protocols (Singer, 2018; Doley, 2017; McClave, 2016; CCCPGC, 2015).

TROUBLESHOOTING NUTRITION CHALLENGES

Common nutrition challenges in this population include the following:

Common Nutrition Challenge	Possible Nutrition Intervention
Hemodynamic instability; need for vasopressors	Trophic enteral nutrition (EN) within 24-48 hours in the amount of 10 kcal/hour to 20 kcal/hour or 500 kcal/day (Martindale, 2017) can help maintain gut mucosal integrity and gut-associated lymphoid tissue and help prevent serious infections.
Aspiration	Correct electrolyte imbalances, elevate head of bed to 30° or greater, perform routine oropharyngeal care; consider post-pyloric feeding tube placement if at high risk for aspiration (Martindale, 2017; McClave, 2016); check gastric residual volumes every four hours, and if elevated (>200mL), consider use of prokinetic medication (Malone, 2017; Martindale, 2017). Electrolyte imbalances can decrease the muscular function and peristalsis of the gastrointestinal tract, causing delayed emptying, thereby increasing the risk of aspiration.
Need for long-term EN	If EN is anticipated to continue for 4 weeks or more, evaluate for percutaneous endoscopic gastrostomy or percutaneous endoscopic jejunostomy feeding tube placement (Martindale, 2017; Fang, 2017) and provide nutrition education regarding rationale for long-term EN to patient and/or caregivers

NUTRITION MONITORING & EVALUATION

Monitoring and evaluation will focus on the same assessment parameters identified in the Nutrition Assessment section.

Suggested Parameters for Ongoing Monitoring

It is important to monitor actual enteral nutrition (EN)/parenteral nutrition (PN) intake compared with goal intake in critically ill patients. Evaluate EN/PN amount received compared with ordered amount and adjust volume or rate as needed to achieve goal volume. Minimize time frames that nutrition is held for repositioning, therapies, and procedures. Adopt a feeding protocol to allow adjustment in rate to make up time that enteral nutrition is held for procedures and tests (Doley, 2017).

Gastrointestinal function—for example, stool output, gastric residual volume, and presence of an abdominal distention—and feeding tolerance may indicate that feeding targets are not being met and therefore should be monitored.

Laboratory data—notably, blood glucose, electrolyte status, renal function, hydration status, acid base status, and inflammatory state (at least qualitatively)—should be monitored to detect metabolic problems such as refeeding syndrome; see Nutrition Support for guidance in managing refeeding syndrome. Monitor renal function, urine output, and intake daily to ensure appropriate hydration status. Acid-base and glycemic status should be monitored daily while providing nutrition support in the critical care setting. If hyperglycemia occurs, it should be treated using the established protocol (Doley, 2017).

Routine monitoring of triglyceride levels in patients on propofol for sedation or receiving lipids as part of a parenteral nutrition regimen is recommended. If triglyceride levels are greater than 400mg/dL, lipids should be decreased or discontinued, and consideration of alternate sedation medication should be considered (Krumpf, 2017; Hise, 2017).

Observations of the effects of critical illness on body composition after admission should be made continually after the initial assessment. Over time, physical characteristics of the critically ill patient will change. Extended bed rest and the catabolic effect of inflammatory response on skeletal muscle will generally cause tissue wasting. If fluid accumulation is present, this may mask the extent of the tissue wasting and keep the body weight at its admission level or even higher.

Ongoing monitoring of vital signs, such as body temperature, along with laboratory data, hemodynamic status, weight, tube and drain output, integumentary status, other forms of treatment, such as dialysis, and gastrointestinal tract function, and nutrition support adjusted as needed (Martindale, 2017).

REFERENCES: CRITICAL ILLNESS

Academy of Nutrition and Dietetics. eNCPT: Nutrition Terminology Reference Manual. Published August 5, 2014. Available at: Website (login required). Accessed July 30, 2019.

Academy of Nutrition and Dietetics Evidence Analysis Library. Critical Illness Guidelines. Published 2012. Available at: Website(login required). Accessed July 29-30, 2019.

Cerra FB, Benitez MR, Blackburn GL, Irwin RS, Jeejeebhoy K, Katz DP, Pingleton SK, Pomposelli J, Rombeau JL, Shronts E, Wolfe RR, Zaloga GP. Applied nutrition in ICU patients: a consensus statement of the American College of Chest Physicians. *Chest*. 1997;111(3):769-778. Doi: 10.1378/chest.111.3.769

Choban P, Dickerson R, Malone A, Worthington P, Compher C; American Society for Parenteral and Enteral Nutrition. A.S.P.E.N. clinical guidelines: nutrition support of hospitalized adult patients with obesity. *JPEN J Parenter Enteral Nutr*. 2013;37:714-744. doi: 10.1177/0148607113499374

Critical Care Clinical Practice Guidelines Committee. Canadian Clinical Practice Guidelines. Updated 2015. Accessed July 29, 2019. Available at: https://criticalcarenutrition.com/resources/cpgs/past-guidelines/2015

Dhaliwal R, Cahill N, Lemieux M, Heyland DK. The Canadian Critical Care Nutrition Guidelines in 2015: An Update on Current Recommendations and Implementation Strategies. *Nutr Clin Pract*. 2015. doi: 10.1177/0884533613510948

Dickerson R, Nitrogen balance and protein requirements in critically ill older patients. *Nutrients*. 2016;8(226):1-14. doi:10.3390%2Fnu8040226

Doley J, Phillips W. Overview of enteral nutrition. In: *The A.S.P.E.N. Adult Nutrition Support Core Curriculum*. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017:213-226.

Evans DC, Collier BR. Trauma, surgery, and burns. In: The A.S.P.E.N. Adult Nutrition Support Core Curriculum. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017: 473-488.

Fang JC, Kinikini M, Enteral Access Devices. . In: The A.S.P.E.N. Adult Nutrition Support Core Curriculum. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017: 227-250.

Frankenfield D. Validation of an equation for resting metabolic rate in older obese critically ill patients. *JPEN J Parenter Enteral Nutr*. 2011;35(2):264-269. doi: 10.1177/0148607110377903

Frankenfield D, Schubert A, Alam S, Cooney RN. An analysis of estimation methods for resting metabolic rate in critically ill adults. *JPEN J Parenter Enteral Nutr*. 2009;33(1):27-36. doi: 10.1177/0148607108322399

Heyland DK, Dhaliwal R, Wang M, Day AG. The prevalence of iatrogenic underfeeding in the nutritionally 'at-risk' critically ill patient: Results of an international, multicenter, prospective study. *Clin Nutr*. 2015;34(4):659-666. doi: 10.1016/j.clnu.2014.07.008

Hise M, Brown JC. Lipids. In: *The A.S.P.E.N. Adult Nutrition Support Core Curriculum*. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017: 71-96.

Hopkins B, Cohen SS, Irvin SR, Alberda C. Achieving Protein Targets in the ICU Using a Specialized High-Protein Enteral Formula: A Quality Improvement Project. *Nutr Clin Pract*. 2019. doi: 10.1002/ncp.10364.

JeVenn AK, Galang M, Hipskind P, Bury C. Malnutrition screening and assessment. In: *The A.S.P.E.N. Adult Nutrition Support Core Curriculum*. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017:185-212.

Kumpf VJ. Complications of Parenteral Nutrition. In: *The A.S.P.E.N. Adult Nutrition Support Core Curriculum*. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017: 345-360.

Malone AM. Complications of Enteral Nutrition. In: *The A.S.P.E.N. Adult Nutrition Support Core Curriculum*. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017: 265-284

Malone A, Hamilton C. The Academy of Nutrition and Dietetics/the American Society for Parenteral and Enteral Nutrition consensus malnutrition characteristics: application in practice. *JPEN J Parenter Enteral Nutr*. 2013;28:639-650. doi: 10.1177/0884533613508435

Marik PE, Zaloga GP. Early enteral nutrition in acutely ill patients: a systematic review. *Crit Care Med*. 2001;29(12):2246-2270. Abstract

McClave SA, Taylor, BE, Martindale RG, Warren MM, Johnson DR, Braunschweig C, , McCarthy MS, Davanos E, Rice TW, Cresci G, Gervasio JM, Sacks GS, Robers PR, Compher C.: 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.). *JPEN J Parenter Enteral Nutr*. 2016;40:159-211. doi: 10.1177/0148607115621863

Mifflin MD, St Jeor ST, Scott BJ, Daugherty SA, Koh YO. A new predictive equation for resting energy expenditure in healthy individuals. *Am J Clin Nutr*. 1990;51:241-247. Doi: 10.1093/ajcn/51.2.241

Martindale RG, Patel JJ, Herron TJ, Codner PA. Sepsis and Critical Illness. In: *The A.S.P.E.N. Adult Nutrition Support Core Curriculum*. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017:457-472.

Mueller C, Compher C, Ellen DM; A.S.P.E.N. Board of Directors. A.S.P.E.N. clinical guidelines: nutrition screening, assessment, and interventions in adults. *JPEN J Parenter Enteral Nutr*. 2011;35:16-24. doi: 10.1177/0148607110389335

Patel R, Parenteral Nutrition Formulations. In: The A.S.P.E.N. Adult Nutrition Support Core Curriculum. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017: 297-300.

Roberts S, Kirsch R. Enteral Nutrition Formulations. In: *The A.S.P.E.N. Adult Nutrition Support Core Curriculum*. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017: 227-250.

Sarav M, Csaba PK. Renal Disease. In: *The A.S.P.E.N. Adult Nutrition Support Core Curriculum*. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017: 565-586.

Singer PA, Blaser AR, Berger MM, Alhazzani W, Calder PC, Casaer MP, Hiesmayr M, Mayer K, Montejo JC, Pichard C, Preiser JC, Van Zanten ARH, Oczkowski S, Szczeklik W, Bischoff SC. ESPEN guideline on clinical nutrition in the intensive care unit. *Clin Nutr*. 2018;38:48-79. doi: 10.1016/j.clnu.2018.08.037

Walker R, Tucker AM, Birtcher KK; Diabetes Mellitus. In: The A.S.P.E.N. *Adult Nutrition Support Core Curriculum*. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017: 675-700.

White JV, Jensen G, Malone A, Schofield M; Academy Malnutrition Work Group; A.S.P.E.N. Malnutrition Task Force; A.S.P.E.N. Board of Directors. 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 J Parenter Enteral Nutr*. 2012;36:275-283. doi: 10.1177/0148607112440285

Winkler MF, Malone AM. Medical Nutrition Therapy in Critical Care. In: Mahan L, Raymond J. Krause's Food & the Nutrition Care Process. 14th Ed. St. Louis, MO: Elsevier; 2017: 775-777.

Young LS,Kim DW . Protein. In: *The A.S.P.E.N. Adult Nutrition Support Core Curriculum*. 3rd ed. Silver Spring, MD: American Society for Parenteral and Enteral Nutrition; 2017: 97-112.