Nutrition Delivery in Critically Ill Patients

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IFA Commentary (MLNGM)

Often overlooked, nutritional fluids with total enteral (TEN) and parenteral nutrition (TPN) form a major part (33%) of fluid volume administration in critically ill patients. This chapter will help to define a reasonable strategy to optimize nutrition in the critical care setting. Some key variables to consider in obtaining nutritional adequacy in combination with the evidence related to optimal amount of calories will be listed. Nutritional deficits will eventually lead to adverse outcomes, and prolonged critical illness will eventually lead to a state of malnutrition. Important clinical level 1 studies and meta-analyses have been published in the past that assist the practicing intensivists in choosing a nutritional support plan for his patients [1–9]. A nutritional screening process should always precede the provision of artificial nutrition. Scores such as the nutritional risk score or the NUTRIC score are imperfect options. The caloric target should be individualized, even though we do not really know if or how many exogenous macronutrients can prevent or correct a nutritional deficit in most of our patients. Indirect calorimetry has never been shown to improve outcome in level one RCTs. The methodology is neither applicable in most ICUs nor in many patients. Therefore, formulas for calculating caloric target are still the recommended albeit flawed tool. There is good evidence for preferring enteral nutrition (EN) over parenteral nutrition (PN), and there are sufficient scientific arguments to advocate early EN within 24–48 h of admission. The gastric residual volume is the most frequently used parameter for monitoring tolerance to EN. As compared to the past, threshold values for intolerance can definitely be relaxed to values of 300 ml and above. Controversy about the risks or benefits of hypocaloric versus normocaloric (feeding to target) feeding has been ongoing for decades. In 2011, the EPaNIC trial showed that during the first week of ICU stay a substantial caloric deficit is not detrimental for outcome and thereby questioned the intrinsic value of PN in this time frame. Strong evidence has emerged from three level 1 trials that at least for the first week of ICU stay there is no benefit from a normocaloric feeding strategy. A hypocaloric regime might even be advantageous for outcome. Indeed, withholding PN and not reaching the currently recommended caloric targets seemed to be of benefit for the vast majority of critically ill patients during the first 7 days. Relevant studies addressing hypocaloric versus normocaloric feeding included the following. In a large, randomized trial (the EDEN trial, $n = 1000$) conducted in critically ill patients with acute lung injury, Rice et al. compared "trickle enteral feeding" to "full enteral feeding" [9]. Trickle feeding resulted in a large cumulative energy debt (after 6 days, a mean of 1300 kcal/d versus 400 kcal/d). However, morbidity and mortality were not different. Follow-up after 1 year also showed no difference for physical function, survival, or multiple secondary outcomes. A second smaller ($n = 305$) randomized trial assessed whether

delivery of 100% of the energy target from day four to eight in ICU with EN plus PN as opposed to only EN could optimize clinical outcome [4]. This controversial study concluded that optimizing individual energy delivery with the aid of indirect calorimetry could reduce nosocomial infections. A third randomized trial addressed early PN versus standard care in 1372 critically ill patients with relative contraindications to early EN [3]. In the standard care group, 29.2% of patients commenced with EN, 27.3% with PN, and 40.8% remained unfed for variable periods of time. There was no significant difference between groups for either the primary end point (death by study day 60) or for ICU or LOS. Time on mechanical ventilation was significantly reduced by 0.47 days with early PN. Finally, subanalysis of the EPaNIC trial showed that a) tolerating a substantial macronutrient deficit early during critical illness did not affect muscle wasting but allowed for faster recovery from weakness and b) that caloric dose had a negative inverse relation with infectious morbidity [2, 5]. Other relevant observations from RCTs of the past 2 years with potential impact for clinical practice include the following: early provision of glutamine or antioxidants did not improve clinical outcomes, and not monitoring gastric residual volume did not increase the rate of VAP [6, 8].

The quality of clinical research aimed at optimizing nutritional strategies in the critically ill has improved significantly in recent years and is filling important knowledge gaps. Strong evidence from several RCTs supports the conclusion that tolerating a substantial caloric deficit in the first 5–7 days of ICU stay will influence mortality or length of stay. However, best evidence indicates that hypercaloric or even normocaloric feeding during this time frame will worsen morbidity.

Therefore, it is time for nutrition stewardship with the 7 D's. Nutrition stewardship is defined, in analogy with fluid stewardship, as a series of coordinated interventions, introduced to select the optimal type of nutrition, dose, and duration of therapy that results in the best clinical outcome, prevention of adverse events, and cost reduction [10]. This can be accomplished by adhering to the 7 D's (definitions, diagnosis, drug, dose, duration, de-escalation, discharge) [10–11]. The first D stands for definitions: correct and uniform definitions should be used when prescribing nutritional therapy. The second D is diagnosis: correct diagnosis should be made, as correct nutritional therapy starts with an adequate assessment of the patient's nutritional status and metabolic evaluation via indirect calorimetry in combination with other monitoring tools, such as BIA and nitrogen balance. Third D is drug: critical care physicians should consider nutrition as drugs that have indications and contraindications, and potential adverse effects, and pay particular attention to the different compounds and their specificities (calories, nitrogen, protein, glucose, lipids, and micronutrients) (Fig. 13.1). For each type of nutrition, there are distinct indications and specific side effects.

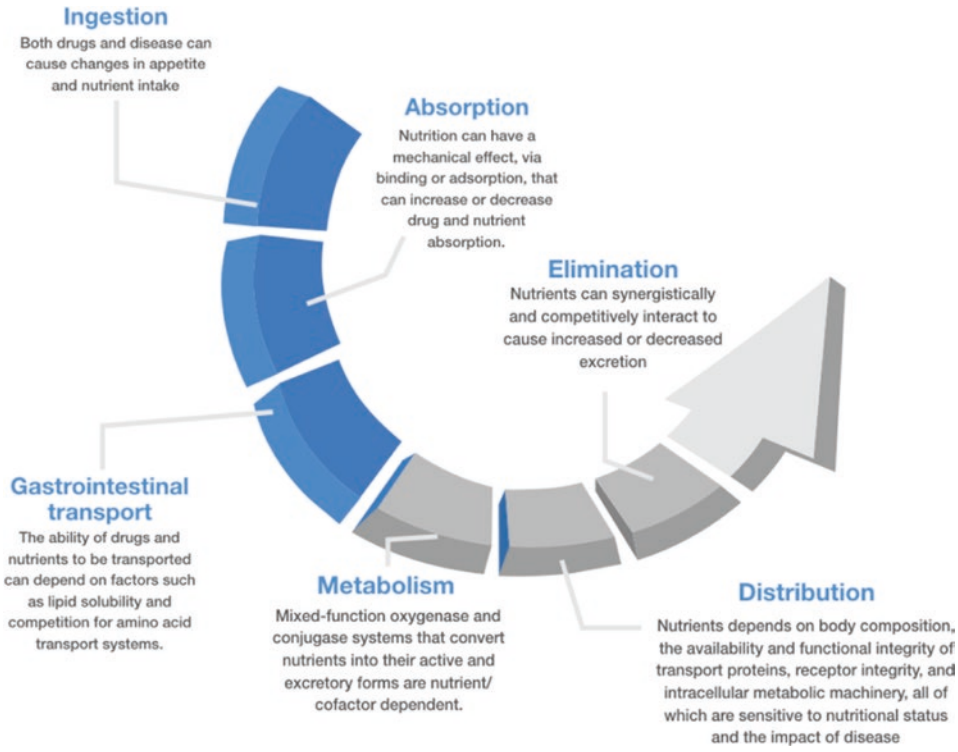

Fig. 13.1 Potential mechanism of nutrients–drugs interaction. Adpated from Pisani D. et al. with permission according to the Open Access CC BY License 4.0 [12]

The fourth D is dose: "sola dosis facit venenum" or "the dose makes the poison." As discussed earlier, there are various important considerations for nutritional prescription, as calorie and protein dosing are correlated with mortality, and pharmacokinetics and dynamics need to be taken into account, as well as volume kinetics, since nutrition may also contribute to fluid accumulation [10, 11]. The fifth D is duration: the duration of total or supplemental artificial nutritional therapy is equally important, and parenteral nutrition must be tapered when shock is resolved and the gastrointestinal tract is normally functioning [13]. The sixth D is de-escalation: the final step in artificial EN or PN nutrition therapy is to consider withholding or withdrawing when they are no longer required. Finally, the seventh D is discharge: correct (dis)continuation or tapering of artificial nutritional therapy and (when needed and indicated) prescription post-discharge from ICU, or hospital, is part of the nutritional care plan and should meet quality standards (Fig. 13.2) [11].

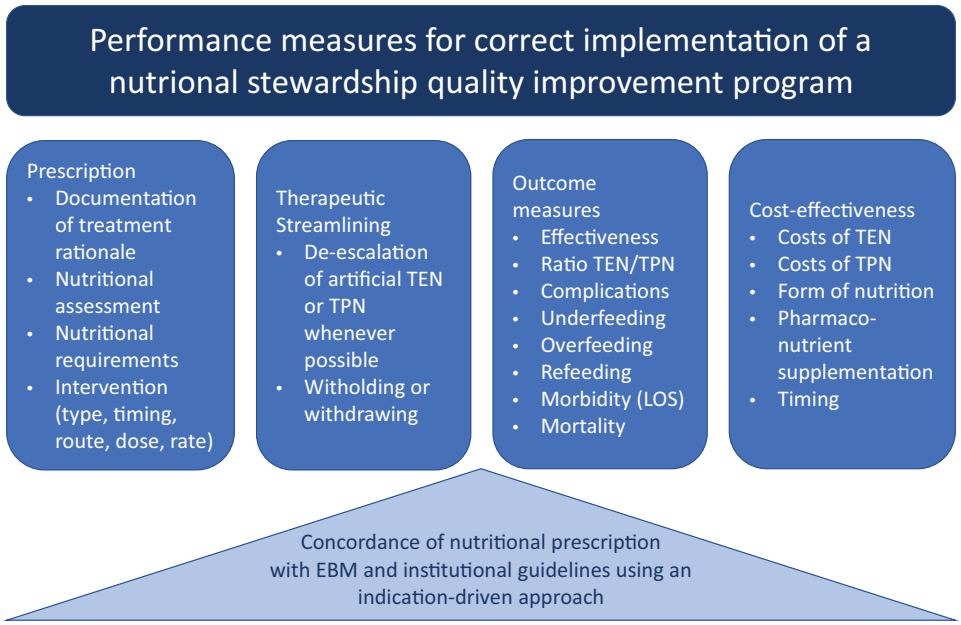

Fig. 13.2 Performance measures for nutritional stewardship program. EBM: evidence-based medicine; ICU: intensive care unit; LOS: length of stay; TEN: total enteral nutrition; TPN: total parenteral nutrition. Adpated from Pisani D. et al. with permission according to the Open Access CC BY License 4.0 [12]

Suggested Reading

1. Casaer MP, Mesotten D, Hermans G, et al. Early versus late parenteral nutrition in critically ill adults. NEJM 2011;365(6):506–517.
2. Casaer MP, Wilmer A, Hermans G, Wouters PJ, Mesotten D, Van den Berghe G. Role of disease and macronutrient dose in the randomized controlled EPaNIC trial: a post hoc analysis. Am J Respir Crit Care Med 2013;187:247–255.
3. Doig GS. Early parenteral nutrition in critically il patients with short-term relative contraindications to early enteral nutrition. JAMA 2013;309:2130–2138.
4. Heidegger CP, Berger MM, Graf S, et al. Optimisation of energy provision with supplemental parenteral nutrition in critically ill patients: a randomised controlled clinical trial. Lancet 2013;381:385–393.
5. Hermans G. Effect of tolerating macronutrient deficit on the development of intensive-care unit acquired weakness: a subanalysis of the EPaNIC trial. Lancet Resp Med 2013;1(8):621–629.
6. Heyland D. A randomized trial of glutamine and oxidants in critically ill patients. NEJM 2013;368:1489–1497.

7. Needha DM et al. One year outcomes in patients with acute lung injury randomised to initial trophic or full enteral feeding. BMJ 2013;346:f1532.
8. Reignier J. Effect of not monitoring residual gastric volume on risk of VAP in adults receiving mechanical ventilation and early enteral feeding. JAMA 2013;309:249–256.
9. Rice TW, Wheeler AP, Thompson BT, et al. National Heart, Lung, and Blood Institute acute respiratory distress syndrome (ARDS) clinical trials network. Initial trophic vs full enteral feeding in patients with acute lung injury: the EDEN randomized trial. JAMA 2012;307(8):795–803.
10. Malbrain MLNG, Van Regenmortel N, Saugel B, De Tavernier B, Van Gaal PJ, Joannes-Boyau O, Teboul JL, Rice TW, Mythen M, Monnet X. Principles of fluid management and stewardship in septic shock: it is time to consider the four D's and the four phases of fluid therapy. Ann Intensive Care 2018 May 22;8(1):66. Doi: 10.1186/s13613-018-0402-x. PMID: 29789983; PMCID: PMC5964054.
11. De Waele E, Malbrain MLNG, Spapen H. Nutrition in sepsis: a bench-to-bedside review. Nutrients 2020;12:395. Doi: 10.3390/nu12020395.
12. Pisani D, Navalesi P, De Rosa S. Do we need a 6D's framework of nutritional stewardship in critical care? J Anesth Analg Crit Care 2021;1(5). Doi: 10.1186/s44158-021-00009-4.
13. Blaser AR, Starkopf J, Alhazzani W, Berger MM, Casaer MP, Deane AM, Fruhwald S, Hiesmayr M, Ichai C, Jakob SM. Early enteral nutrition in critically ill patients: ESICM clinical practice guidelines. Intens Care Med 2017, 43, 380–398. [Google Scholar] [CrossRef].

Learning Objectives

The learning objectives of this chapter are:

1. To understand "medical nutrition therapy" and goals of nutrition in intensive care unit (ICU).
2. To explain nutrition assessment in critically ill patients admitted to ICU.
3. To learn assessment of energy expenditure in critically ill patients.
4. To learn how to start enteral nutrition (EN) in critically ill patients.
5. To explain the dosing, monitoring of tolerance, and adequacy of EN.
6. To help the clinician with selection of appropriate EN.
7. To learn the indications of parenteral nutrition (PN).
8. To assist in diet formulation in special medical conditions like pulmonary failure, renal failure, hepatic failure, acute pancreatitis, trauma, sepsis, burns, postoperative case of major surgery, and obese patients.
9. To understand the impact of nutrition on fluid therapy and accumulation.
10. To introduce nutrition stewardship.

Case Vignette

A 57-year-old man was admitted to ER with history of 3 days of increasing shortness of breath, sputum production, and fever. He had a past medical history of diabetes, hypertension, and alcoholism. He did not consume alcohol since the last 3 days. He had around 8–10 kg weight loss over the past 2 months due to poor oral intake. Past surgical and family histories were not significant. On examination, the patient appeared anxious and diaphoretic. There was no jugular venous distension. Bitemporal wasting was present. There were cold and clammy skin and extremities. There were ronchi and bronchial breath sounds over the right axillae. The remainder of the clinical examination was unremarkable. Vital signs were as follows: heart rate 110/min, blood pressure 90/40 mmHg, respiratory rate 26/min, temperature 38.9 °C, and Spo2 84% on room air. The body mass index (BMI) was 19.9. Laboratory values are as follows: white blood cell count 19500 per microliter, serum potassium 2.8 mmol/L, phosphate 1.4 mg/dL, magnesium 1.1 mg/dL, bicarbonate 18 mmol/L, serum creatinine 2.8 mg/dL, and lactic acid 6 mmol/L. Serum albumin level was 1.8 g/dL. Arterial blood gas shows pH of 7.32, partial pressure carbon dioxide of 40 mmHg, partial pressure oxygen of 76 mmHg, and oxygen saturation of 90% on 10 liters oxygen. Chest radiograph shows right middle lobe opacity. Clinical diagnosis was sepsis with acute hypoxemic respiratory failure secondary to community acquired pneumonia.

Questions

Q1. What is the role of nutrition in a critically ill patient in the ICU?
Q2. How will you assess nutritional risk in this patient?
Q3. What will be the nutritional management strategy for this patient?

Introduction

Critical illness is a state of catabolic stress in which the patient shows a systemic inflammatory response along with complications of increased risk for infections, multiple-organ dysfunction, prolonged hospitalization, and disproportionate mortality. Traditionally, nutrition support in critically ill patients was regarded as adjunctive care designed to provide exogenous fuels to preserve lean body mass and support the patient during the stress response. Recently, this strategy has changed to medical nutrition therapy, in which feeding is thought to help attenuate the metabolic response to stress, prevent oxidative cellular injury, and favorably modulate immune responses. Delivering early nutrition therapy, primarily by the enteral route, is seen as a proactive therapeutic strategy that may maintain

gut integrity, reduce disease severity, diminish complications, decrease length of stay (LOS) in the ICU, and favorably impact patient outcomes. In recently published guidelines, the term "medical nutrition therapy" has replaced "artificial nutrition." This term encompasses oral nutritional supplements, enteral nutrition (EN), and parenteral nutrition (PN) [1, 2]. Nutrition is one indication for fluid therapy, intravenous fluids to cover the other indications: resuscitation, replacement and maintenance are discussed elsewhere. More information on crystalloid solutions can be found in Chap. 9, albumin is discussed in Chap. 10, and other colloid solutions like starches and gelatins are discussed in Chap. 11.

Goals of Nutrition in the ICU

1. To preserve the lean body mass.
2. To maintain the immune function.
3. To avoid metabolic complications.

Nutrition Assessment

General clinical assessment should be performed to assess nutrition status in every critically ill patient admitted to the ICU [2]. This should include a detailed history of percentage weight loss (if any) in the last 6 months, appetite, nausea, food intake or decrease in physical performance before ICU admission, and physical examination focusing on body composition, muscle mass, and strength, where possible [3]. Weight loss of 20–30% suggests moderate protein calorie malnutrition, while 30% or greater indicates severe protein calorie malnutrition. Weight loss of 10% or greater over a short span of time is also clinically important. [4] The general appearance of a patient with emphasis on the temporalis and upper extremity wasting of skeletal muscle mass provides a quick, inexpensive, and clinically useful measure of nutritional status.

Formal assessment of nutrition status is performed using a nutrition scoring system, several of which exist. Examples include (1) subjective global assessment (SGA), (2) malnutrition universal screening tool (MUST), (3) nutritional risk screening (NRS), (4) mini nutritional assessment (MNA), and (5) NUTRIC score.

Although many of these scoring systems have not been validated in critically ill patients, the American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines have recommended determination of nutrition risk by NRS score or NUTRIC score on all patients admitted to the ICU. As per the European Society for Clinical Nutrition and Metabolism (ESPEN) guidelines, NRS 2002 and MUST scores are easy and quick in calculation and have the strongest predictive value for mortality. Among the assessment tools available, SGA is inexpensive, quick, and can be conducted at the bedside. It is a reliable tool for determining outcomes in critically ill patients. High nutrition risk scores identify those patients most likely to benefit from early EN therapy. To complete the nutrition

assessment, the history of comorbid conditions, function of the gastrointestinal (GI) tract, and aspiration risk must be evaluated.

Traditional nutrition indicators or surrogate markers are not validated in critical care. For example, traditional serum protein markers (albumin, prealbumin, transferrin, retinol binding protein, total lymphocyte count) are a reflection of the acute-phase response (increases in vascular permeability and reprioritization of hepatic protein synthesis) and hence do not accurately depict nutrition status in the ICU setting. Similarly, anthropometrics (body mass index, triceps skin fold thickness, mid-arm circumference area) are not reliable in assessment of nutrition status or adequacy of nutrition therapy. Individual levels of calcitonin, C-reactive protein, interleukin-1, tumor necrosis factor, interleukin-6, and citrulline are still under investigation as to their utility and should not be used as surrogate markers.

Ultrasound is emerging as a tool to expediently measure muscle mass and determines changes in muscle tissue at the bedside in the ICU, given its ease of use and availability. A computed tomography (CT) scan provides a precise quantification of skeletal muscle and adipose tissue depots; however, this would be unfeasible given the prohibitive cost and radiation exposure unless a scan is coincidently being performed for other clinical indication.

Assessment of Energy Needs

In critically ill patients on mechanical ventilation, energy expenditure (EE) can be most accurately determined by indirect calorimetry. However, in the absence of indirect calorimetry, a simple weight-based eq. (25–30 kcal/kg/d) would be adequate in determining energy requirements [5].

Initiate Early EN

Medical nutrition therapy should be considered for all patients admitted to the ICU for more than 48 h [6]. Enteral feeding preserves gut integrity and barrier and immune function. Oral diet is preferred over EN or PN in critically ill patients who are able to eat. If oral intake is not possible, early EN (within 48 h) should be initiated. Presence of bowel sounds is not a prerequisite for initiation of EN. Where there are contraindications to oral feeding and EN, early PN should be implemented within 3–7 days in severely malnourished patients. EN/PN feed should be gradually increased to the calorie target to avoid overfeeding. Gastric access should be used as the standard approach for EN. Post-pyloric feeding is a suitable alternative in patients with gastric feeding intolerance not resolved with prokinetic agents (intravenous erythromycin/metoclopramide). For patients at high risk for aspiration, post-pyloric, mainly jejunal, feeding should be considered. Continuous rather than bolus EN may have an advantage and is a must in post-pyloric feeding.

Early EN is preferred especially in the following conditions:

1. Patients receiving neuromuscular blocking agents, in prone position, and on ECMO.
2. Patients with traumatic brain injury (TBI), stroke (ischemic or hemorrhagic), and spinal cord injury.
3. Patients with severe acute pancreatitis, GI surgery, and open abdomen.
4. Patients after abdominal aortic surgery.
5. Patients with abdominal trauma when the continuity of the GI tract is confirmed/restored.
6. Regardless of the presence of bowel sounds unless bowel ischemia or obstruction is suspected in patients with diarrhea.

In following conditions, early EN should be delayed:

1. If shock is uncontrolled and hemodynamic and tissue perfusion goals are not reached, low dose EN can be started as soon as shock is recovered with fluids and vasopressors/inotropes while remaining vigilant for signs of bowel ischemia.
2. In case of uncontrolled life-threatening hypoxemia, hypercapnia, or acidosis. However, EN can be started in patients with stable hypoxemia and compensated or permissive hypercapnia and acidosis.
3. In the presence of active upper GI bleeding, EN can be started when the bleeding has stopped and no signs of re-bleeding are observed.
4. Patients with overt bowel ischemia.
5. Patients with high-output intestinal fistula if reliable feeding access distal to the fistula is not achievable.
6. Patients with abdominal compartment syndrome.
7. If gastric aspirate volume is above 500 ml/6 h.

Dosing of EN

If predictive equations are used to estimate the energy need, hypocaloric nutrition (below 70% estimated needs) is preferred over isocaloric nutrition in the early phase of acute illness. After day three, caloric delivery can be increased to 80–100% of measured EE. During critical illness, protein requirement is expected to be 1.2–2.0 g/kg actual body weight per day and is likely to be higher in burns or multitrauma patient [7]. The amount of carbohydrates administered to ICU patients should not exceed 5 mg/kg/min [8].

Low-dose EN should be administered in the following situations:

1. Patients receiving therapeutic hypothermia with an increased dose after rewarming.
2. Patients with intra-abdominal hypertension without abdominal compartment syndrome: temporary reduction or discontinuation of EN should be considered if intra-abdominal pressure values increase during EN.

3. Patients with acute liver failure when acute, immediately life-threatening metabolic derangements are controlled with or without liver support strategies, independent of grade of encephalopathy.

Monitoring Tolerance and Adequacy of EN

Patients should be monitored daily for tolerance of EN. Ordering a feeding status of nil per os (NPO) for diagnostic tests or procedures should be minimized to limit propagation of ileus and to prevent inadequate nutrient delivery. Gastric residual volume should not be used as part of routine care to monitor ICU patients receiving EN. A volume-based feeding protocol or a top-down multistrategy protocol should be considered.

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.

EN should not be automatically interrupted for diarrhea but rather that feeding should be continued while evaluating the etiology of diarrhea in an ICU patient to determine appropriate management.

Where there are contraindications to oral feeding and EN, early and progressive PN should be implemented within 3–7 days in severely malnourished patients.

Selection of Appropriate Enteral Formulation

A standard isotonic polymeric formula should be used for the initiation of EN in the ICU setting. Avoid the routine use of all specialty formulas in critically ill patients in a medial ICU and disease-specific formulas in the surgical ICU.

Immune-modulating enteral formulations (arginine with other agents, including eicosapentaenoic acid [EPA], docosahexaenoic acid [DHA], glutamine, and nucleic acid) should not be used routinely in the medical ICU. Except for burns and trauma patients, supplemental enteral glutamine(0.2–0.3 g/kg/d) should not be added to an EN regimen routinely in critically ill patients.

In unstable and complex ICU patients, particularly in those with hepatic and renal failure, parenteral glutamine should not be administered [9]. High doses of omega-3-enriched enteral formulas should not be given on a routine basis. The same holds true for other supplements like selenium, arginine, or vitamin C.

When to Use PN

ASPEN guidelines recommend that use of supplemental PN should be considered after 7–10 days if unable to meet >60% of energy and protein requirements by the enteral route alone in patients with both low and high nutrition risk. 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. In the patient at low nutrition risk (e.g., NRS 2002 ≤3 or NUTRIC score ≤5), exclusive PN should be withheld over the first 7 days following ICU admission if unable to maintain volitional intake and if early EN is not feasible.

In the patient determined to be at high nutrition risk (e.g., NRS 2002 ≥ 5 or NUTRIC score ≥5) or severely malnourished, when EN is not feasible, ASPEN guidelines recommend initiating exclusive PN as soon as possible following ICU admission.

ESPEN guidelines recommends PN in patients who do not tolerate full-dose EN during the first week in the ICU. PN should not be started until all strategies to maximize EN tolerance have been attempted.

When Indicated, Maximize Efficacy of PN

ASPEN guidelines recommend that hypocaloric PN dosing (≤20 kcal/ kg/d or 80% of estimated energy needs) with adequate protein (≥1.2 g protein/kg/d) should be considered in appropriate patients (high risk or severely malnourished) requiring PN, initially over the first week of hospitalization in the ICU.

The target blood glucose range is 140–180 mg/dL for the general ICU population. As tolerance to EN improves, the amount of PN energy should be reduced and finally discontinued when the patient is receiving >60% of target energy requirements from EN.

Special Situations

Pulmonary Failure

ASPEN guidelines recommend that high-fat/low-carbohydrate formulations designed to manipulate the respiratory quotient and reduce CO_2 production should not be used in ICU patients with acute respiratory failure. Fluid-restricted energy-dense EN formulations should be considered for patients with acute respiratory failure (especially in the presence of volume overload). Serum phosphate level should be monitored closely when appropriate and phosphate replacement when needed.

Renal Failure

ASPEN guidelines recommend that ICU patients with acute kidney injury (AKI) should be placed on a standard enteral formulation (protein 1.2–2 g/kg actual body weight per day and energy 25–30 kcal/kg/day). Patients on renal replacement experience a loss of protein along with vitamins and micronutrients which can affect the patient adversely. Protein

calorie malnutrition is an independent predictor of mortality in AKI patients. Energy consumption is not increased and is only 130% of REE. The loss (selenium, zinc, fat, lactate, glucose) is termed as "depletion syndrome."

A higher energy prescription do not induce a more positive nitrogen balance and is associated with a higher incidence of hyperglycemia and hypertriglyceridemia and a more positive fluid balance.

Energy provision should be composed of 3–5 (maximum 7) g per kilogram body weight carbohydrates and 0.8–1.0 g per kilogram body weight fat (KDIGO 2012) [10].

Administer 0.8–1.0 g/kg/d of protein in noncatabolic AKI patients without need for dialysis (KDIGO 2012) [10].

Administer 1.0–1.5 g/kg/d of protein in patients with AKI on RRT (KDIGO 2012, 2D) [12] up to a maximum of 1.7 g/kg/d in patients on CRRT and in hypercatabolic patients (KDIGO 2012) [10].

Hepatic Failure

ASPEN guidelines recommend that standard enteral formulations should be used in ICU patients with acute and chronic liver disease. Dry weight should be used instead of actual weight in predictive equations to determine energy and protein in patients with cirrhosis and hepatic failure, due to complications of ascites, intravascular volume depletion, edema, and hypoalbuminemia. There is no evidence of benefit of branched-chain amino acid (BCAA) formulations in patients with encephalopathy.

Acute Pancreatitis

Patients with moderate to severe acute pancreatitis should have a naso−/oroenteric tube placed and EN started at a trophic rate and advanced to goal as fluid volume resuscitation is completed (within 24–48 h of admission). EN should be provided to patients with severe acute pancreatitis by either the gastric or jejunal route, as there is no difference in tolerance or clinical outcomes between these two levels of infusion.

Trauma

Similar to other critically ill patients, early enteral feeding with a high-protein polymeric diet should be initiated in the immediate post-trauma period (within 24–48 hours of injury) once the patient is hemodynamically stable. Either arginine-containing immune-modulating formulations or EPA/DHA supplement with standard enteral formula are appropriate in patients with traumatic brain injury.

Table 13.1 Nutritional recommendations in sepsis

Nutrient	Recommended dose
Caloric needs	Determined by indirect calorimetry
Protein	0.8–1.3 g/kg/day
Lipids	0.7–1.5 g/kg/day
Glucose	1–1.5 g/kg/day
Glutamine	<0.35 g/kg/day IV or <0.5 g/kg/day enterally in TPN fed patients
Fluid	1 mL/kg/h

TPN Total Parenteral Nutrition

Burns

EN should be provided to burn patients whose GI tracts are functional and for whom volitional intake is inadequate to meet estimated energy needs. PN should be reserved for those burns patients for whom EN is not feasible or not tolerated. Patients with burn injury should receive protein in the range of 1.5–2 g/kg/d.

Sepsis

Critically ill patients should receive EN therapy within 24–48 h of the diagnosis of severe sepsis/septic shock as soon as resuscitation is complete and the patient is hemodynamically stable. Trophic feeding (defined as 10–20 kcal/h or up to 500 kcal/d) should be provided for the initial phase of sepsis, advancing as tolerated after 24–48 h to >80% of target energy goal over the first week with a target protein delivery of 1.2–2 g /kg/d (Table 13.1).

Postoperative Major Surgery

EN should be provided when feasible in the postoperative period within 24 h of surgery, as it results in better outcomes than use of PN. Routine use of an immune-modulating formula (containing both arginine and fish oils) in the SICU for the postoperative patient who requires EN therapy. In a patient who has undergone major upper GI surgery and EN is not feasible, PN should be initiated early (only if the duration of therapy is anticipated to be ≥7 days).

Obese Patients

An iso-caloric high-protein diet can be administered with energy intake guided by indirect calorimetry if available. If indirect calorimetry is unavailable, energy intake can be based on "adjusted body weight" calculated as ideal body weight + 1/3 actual body weight.

Protein delivery should be guided by urinary nitrogen losses or lean body mass determination (using CT or other tools). If urinary nitrogen losses or lean body mass determinations are not available, protein intake can be 1.3 g/kg "adjusted body weight"/day.

Fluid Therapy and Nutrition

It has to be understood that nutrition and fluid therapy go hand in hand and nutrition therapy may be a major cause of fluid creep. The intensivist has to be vigilant while calculating the amount of fluid to be given to the patient when there is ongoing parenteral/enteral nutrition. He should be mindful that he is injecting a hyperosmolar fluid in the form of parenteral nutrition to the critically ill which has its own complications (electrolyte disturbances, hyperglycemia). The following points regarding **"**volume" and "electrolytes" should be noted:

1. TPN should not be used to completely replenish the fluid requirement of the patient. The intensivist must provide a "*maintenance fluid*" in addition to TPN.
2. As large amounts of fluid are being prescribed, it is crucial to assess the "need for fluid restriction," to "avoid volume overload," particularly in patients with congestive heart failure and renal failure.
3. There should be judicious use of ultrasound and dynamic parameters to assess fluid responsiveness while using fluid therapy along with nutrition; fluid overloading must be avoided.
4. Regular (12 hourly) electrolyte checks are necessary in patients on EN and PN. A standard TPN has 30–80 meq/L of sodium, 30–40 meq/L of potassium, 4–12 meq/L of magnesium, and 10–15 mmol/L of phosphate. So potassium, magnesium, and phosphate replacement should be considered with the initiation of parenteral therapy.

Case Vignette
Questions and Answers

Q1. What is the role of nutrition in a critically ill patient in the ICU?

A1. The earlier case scenario is very common in the ICU. Triggers such as trauma, infections, respiratory failure, and burns activate the metabolic response to stress which culminates in uncontrolled catabolism and resistance to anabolic signals, leading to proteolysis. Uncontrolled catabolism leads to a cumulative calorie deficit. Combination of proteolysis, stress-mediated anabolic resistance, immobilization, and muscle disuse accelerates loss of muscle mass. Loss of lean body mass has been associated with muscle weakness, poor wound healing, mechanical ventilator dependency, increased risk for nosocomial infection, increased hospital length of stay, and increased morbidity and mortality. Exogenous nutrient delivery via enteral or parenteral routes can provide sufficient calories, micronutrients, and antioxidants for energy substrate repletion and maintenance of daily caloric balance.

Q2. How will you assess nutritional risk in this patient?
A2. Patient is a 57-year-old man with a past medical history of diabetes, hypertension, and alcoholism admitted for respiratory failure and sepsis secondary to community-acquired pneumonia. The patient's history of poor oral intake and weight loss suggests pre-hospitalization malnutrition. Age, comorbidities, and severity of current illness leading to critical illness place this patient at high nutritional risk (NUTRIC score ≥ 5), suggesting he may have poor outcomes due to a lack of nutrition or insufficient nutrition. The patient also has major risk factors for refeeding syndrome.
Q3. What will be the nutritional management strategy for this patient?
A3. High nutritional risk suggests the patient will benefit from early nutrition. However, the patient's preexisting malnutrition (history of poor oral intake and weight loss) and significant electrolyte depletions put the patient at risk for refeeding syndrome, which may limit early aggressive nutrition. The patient has no reported contraindications for EN, which include hemodynamic instability requiring escalating vasopressor support, vomiting, ileus, active gastrointestinal bleed, and bowel ischemia. So EN is recommended using a standard (isocaloric) formula with a goal calorie prescription of 25 kcal/kg/day and at least 1.2 g/kg/day protein. EN would be started through a nasogastric tube at an initial rate of 10–20 mL/h and titrated to goal slowly while monitoring for refeeding syndrome. Serum phosphate, potassium, and magnesium should be checked frequently for repletion. Since the protein goal will not be achieved using a trophic EN rate, additional enterally delivered supplemental protein can be added. If the patient does not tolerate EN, early exclusive PN has been demonstrated to be safe and efficacious for calorie provision.

Conclusion

Nutrition stewardship is defined, in analogy with fluid stewardship, as a series of coordinated interventions, introduced to select the optimal type of nutrition, dose, and duration of therapy that results in the best clinical outcome, prevention of adverse events, and cost reduction. This can be accomplished by adhering to the 6 D's (diagnosis, drug, dose, duration, de-escalation, discharge).

Diagnosis Correct nutrition therapy starts with an adequate assessment of the patient's nutritional status (including body weight and body mass index, laboratory analysis with kidney function and electrolytes, urine analysis, etc.) and metabolic evaluation via indirect calorimetry in combination with other monitoring tools, such as body composition assessed with bio-electrical impedance analysis and nitrogen balance.

Drug Critical care physicians should consider nutrition as any other drug administered to our patients with distinct indications and contraindications and potential adverse and side effects. Particular attention should be paid to the different compounds and their specifications (calories, nitrogen, protein, glucose, lipids, and micronutrients).

Dose "Sola dosis facit venenum" or "only the dose makes the poison." There are various important considerations while prescribing a nutritional formula, not only calories and protein dosing as they are correlated with mortality, but also pharmacokinetics and pharmacodynamics need to be taken into account, as well as volume kinetics, since nutrition may also contribute to fluid accumulation.

Duration The duration of total or supplemental artificial nutritional therapy is equally important.

De-escalation The final step in artificial EN or PN nutrition therapy is to consider tapering, withholding, or withdrawing when they are no longer required, e.g., when shock is resolved and the gastrointestinal tract is normally functioning.

Discharge Correct (dis)continuation or tapering of artificial nutritional therapy and (when needed and indicated) prescription post-discharge from ICU, or hospital, is part of the nutritional care plan and should meet quality standards.

Take-Home Messages

- All the critically ill patients should undergo nutrition assessment, on admission by well-qualified and trained nutritionists using SGA/NRS/NUTRIC/MUST score as per local ICU protocol.
- Observation of signs of malnutrition (e.g., cachexia, edema, muscle atrophy, BMI <20 kg/m^2) is critical.
- Enteral nutrition should be started early, preferably within the first 24–48 h.
- The nasogastric route should be the first choice of enteral feeding.
- Continuous formula feeding with pumps or gravity bags can be preferably done via fine bore (8F–12F) tubes.
- Feeding should be tailored as per the patient's requirement and level of tolerance.
- Calories should be in range of 25–30 Kcal/kg body weight/ day for most critically ill patients.
- Protein requirement for most critically ill patients is in the range of 1.2–2.0 g/kg body weight/day.
- Scientific formula feeding should be preferred over blended feeding to minimize contamination.
- In case the nutrition requirement is not met adequately with EN even after 7 days of ICU admission, then usage of parenteral nutrition (PN) may be considered.
- Give sufficient insulin for glycemic control using established protocols.

- Calorie deficits must be avoided because it is harder to catch up.
- It is time for nutrition stewardship taking into account the 4 D's: drug, dose, duration, de-escalation.

References

1. Singer P, Berger MM, Van den Berghe G, Biolo G, Calder P, Forbes A, et al. ESPEN guidelines on parenteral nutrition: intensive care. Clin Nutr. 2009;33:246e51.
2. Singer P, Blaser AR, Berger MM, Alhazzani W, Calder PC, et al. ESPEN guideline on clinical nutrition in the intensive care unit: intensive care. Clin Nutr. 2018;38:48. https://doi.org/10.1016/j.clnu.2018.08.037.
3. Singer P, Weinberger H, Tadmor B. Which nutrition regimen for the comorbid complex intensive care unit patient? World Rev Nutr Diet. 2013;105:169e74.
4. Sheean PM, Peterson SJ, Chen Y, Liu D, Lateef O, Braunschweig CA. Utilizing multiple methods to classify malnutrition among elderly patients admitted to the medical and surgical intensive care units (ICU). Clin Nutr. 2013;32:752e7.
5. Taylor BE, McClave SA, Martindale RG, Warren MM, Johnson DR, Braunschweig C, et al. 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.). Crit Care Med. 2016;44:390e438.
6. Reintam Blaser A, Starkopf J, Alhazzani W, Berger MM, Casaer MP, Deane AM, et al. Early enteral nutrition in critically ill patients: ESCIM clinical practice guidelines. Intensive Care Med. 2017;43:380e98.
7. Zusman O, Theilla M, Cohen J, Kagan I, Bendavid I, Singer P. Resting energy expenditure, calorie and protein consumption in critically ill patients: a retrospective cohort study. Crit Care. 2016;20:367.
8. Burke JF, Wolfe RR, Mullany CJ, Mathews DE, Bier DM. Glucose requirements following burn injury. Parameters of optimal glucose infusion and possible hepatic and respiratory abnormalities following excessive glucose intake. Ann Surg. 1979;190:274e85.
9. Heyland DK, Elke G, Cook D, Berger MM, Wischmeyer PE, Albert M, et al. Glutamine and antioxidants in the critically ill patient: a post hoc analysis of a large-scale randomized trial. J Parenter Enter Nutr. 2015;39:401e9.
10. KDIGO 2012;Vol 2, Issue 1.