REVIEW ARTICLE

Nutrition in ICU Patients

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Abstract

Critically ill patients need appropriate nutritional supplementation for their energy requirements during their intensive care unit (ICU) stay and even after ICU stay.[1] Any critical illness is a catabolic state and all critically ill patients have an ongoing low-grade inflammation and protein catabolism referred to as persistent inflammatory catabolism syndrome (PICS).[2] Adequate supplementation of nutrition attenuates the stress response and modulates immune responses. The aim of nutritional supplementation is to supplement both macro- and micronutrient requirements. Careful supplementation of protein and caloric intake can avoid under- and overfeeding and will decrease the hospital stay and morbidity. Route of supplementation, that is, oral, enteral, or parenteral depends on the patient's hemodynamic status and gastrointestinal functioning. Initiation of feeding within 24–48 hours of critical illness has been recommended. Also, early start of physical exercise has favorable effect on muscle preservation and reduces protein catabolism. The patient's outcome in intensive care depends upon the timing of nutrition, amount, and type of nutrition.

Keywords: Catabolism, Critical illness, Enteral, Guidelines, Multiorgan failure, Parenteral.

Research and Innovation in Anesthesia (2019): 10.5005/jp-journals-10049-0071

Introduction

The advancements and improvements in critical care have led to an increased emphasis on nutritional support, which is no longer considered merely supportive but is an important therapeutic pillar of critical care. The requirements of patients in the intensive care unit (ICU) vary depending upon the etiology and phase of their illness and hospitalization. These patients often have multiorgan involvement, hemodynamic alterations, and undergo drastic changes in metabolism as well as body composition superimposed with the effects of systemic inflammatory response which increase the risk of malnutrition.[3] To consider all these factors while ascertaining the routes, formulations, goals, monitoring, and complications of nutritional therapy for the patient warrants consistent review and restructuring based on evolving research and guidelines.

Basics of Metabolic Changes and Nutrition in Critically Ill Patients

Sir David Cuthbertson studied the changes in metabolism after injury or infection and labeled them as the phases of Ebb and Flow.[4] The Ebb phase, as the name suggests, is associated with decreased metabolism, hypoperfusion, and hyperglycemia lasting for 12–24 hours. Hyperglycemia under the influence of stress hormones like glucagon, cortisol, and catecholamines is primarily due to glycogenolysis.

The flow phase follows from 48 hours (early period) to the subsequent week (late period) wherein there is a tremendous increase in catabolism and consequent energy requirement. White blood cells, fibroblasts, and granulation tissue, as well as the brain depend on glucose, which can be metabolized to provide energy even in the absence of oxygen or well-developed mitochondria. Lactate, alanine (from muscle breakdown), and other amino acids undergo gluconeogenesis after the glycogen stores of the liver are depleted. Proteolysis and lipolysis also contribute to energy production.

The patient then either proceeds on the path to recovery with an anabolic phase of resynthesis during convalescence or the patient may deteriorate into chronic critical illness. This may continue for weeks with an increased resting energy expenditure (REE) and severe catabolism. An increase in insulin resistance associated with hyperglycemia is also seen and nutrients are derived primarily from proteolysis and lipolysis leading to wasting and loss of lean body mass. The importance of nutrition therapy can be gauged from the estimate that the protein breakdown in sepsis is almost 260 g (equivalent to loss of 1 kg muscle) per day.[5] Thus, if patients do not receive adequate nutrient replacement, muscle tissue will be lost rapidly and the immune response will weaken, hampering ventilatory weaning and subsequent recovery.

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How to cite this article: Kharat P, Vithani S, Gvalani SK. Nutrition in ICU Patients. Res Inno in Anesth 2019;4(2):40–44.

Source of support: Nil

Conflict of interest: None

Practical Guidelines for Assessment of Nutrition in Critically Ill Patients

- Well-qualified and trained nutritionists dedicated to the ICU must work hand-in-glove with the intensivists to assess, plan, and guide nutritional supplementation. Target ratio of nutritionist-to-critically ill patient must be around 1:25.[6]
- A thorough assessment should be performed on admission as well as every subsequent day to assess nutritional status of the patient in the ICU. This should encompass details from the patient and/or family of pre-admission nutrient intake, unintentional weight loss or decrease in physical performance, physical examination, general assessment of body composition, and muscle mass and strength, if possible.[7]

- Nutrition status of Indian malnourished patients can be assessed by bedside subjective global assessment (SGA) which is inexpensive, quick, and reliable.[6]
- Harris-Benedict Equation for REE in a healthy afebrile individual:[8]

For males: BMR = 13.75 × weight (kg) + 5 × height (cm) − 6.78 × age (years) + 66	Modification of REE as per associated condition:	REE increases by:
For females: BMR = 9.56 × weight (kg) + 1.85 × height (cms) − 4.68 × age (years) + 655	Fever (per 1°C above 37°C up to 40°C)	10%
This usually comes to 25 kcal/kg/day.	Sepsis	9%
	Surgery	6%
	Burns	100%

- However, indirect calorimetry is a better tool to assess REE rather than predictive equations which may be erroneous, often up to 60%. VO_2 (oxygen consumption) from pulmonary arterial catheter or VCO_2 (carbon dioxide production) derived from the ventilator can also be used to deduce REE if indirect calorimetry is unavailable.[7]
- Computed tomography or ultrasonography can be used to ascertain lean body mass - BMI is unreliable because it is affected by fluid administration and may not reflect the real status of muscle wasting.
- All patients staying in the ICU for > 48 hours must be considered at risk of malnutrition and thus must be started on nutrition therapy.[7]
- Once the timing and the route of nutrition is decided, the energy goal should be gradually pursued over the first 48 hours to avoid overnutrition.[7]
- Nutrition not exceeding 70% of EE should be administered in the early phase of acute illness and caloric delivery can be increased up to 80–100% of measured EE after 72 hours.[7]
- Drug–nutrient interactions can occur and hence must be measured daily along with the electrolyte concentration.
- Scientific, closed system ready-to-hang formula feeds should be preferred over blenderized feeds (more prone to bacterial contamination). Hygienic conditions must be emphasized on while preparing, storing, and administering these feeds.

Components of Nutrition Therapy

Nutrition therapy aims at meeting not only the macronutrient but also the micronutrient requirements in critically ill patients.

The macronutrients protein, lipid, and carbohydrate meet the energy needs whilst micronutrients (vitamins and minerals) are required in small amounts to maintain homeostatic and immune functions.

- **Protein**—Provides 5.3 kcal/g
  Daily requirement: 1.5 g/kg/day (range 1.2 to 2.0 g/kg/day for ICU patients). Use 2 g/kg/day if severely catabolic, e.g., severe sepsis/burns/trauma.
- **Lipid**—Provides 9.3 kcal/g
  Calories from lipid should be limited to 40% of total calories. Intravenous lipid (including nonnutritional lipid sources) <1.5 g lipids/kg/day and should be customized to patient tolerance.[7]
- **Carbohydrate**—Provides 3.75 kcal/g *in vivo*. The amount of glucose (PN) or carbohydrates (EN) administered to ICU patients should not exceed 5 mg/kg/minute.[7]
  Give the remaining energy requirements as carbohydrate.

Micronutrients

While considering nutritional supplementation, we always tend to skip on micronutrients. But it has been realized and proved that deficiency of these micronutrients leads to impaired immunity, poor wound healing, and increased of rate morbidity/mortality.[9] Addition of these trace elements and minerals can have a great impact on improvement of survival of the poorly nourished and high-risk individuals. These micronutrients also play an important role as catalyst in various enzyme metabolisms.[7] Selenium is one of the most important micronutrients. There is no need to supplement these nutrients in patients that are already on formula feeds.[10] These must be added to blenderized feeds and those on parenteral feeds.

Route of Nutrition

Route of administration of nutrients (enteral or parenteral) needs to be decided based on various factors including general condition, hemodynamic status, and gastrointestinal functioning.[11] Early enteral nutrition (EEN) in critically ill patient is found to be associated with many benefits and decreased complications.[12] Initiating feeding within 24–48 hours of critical illness is defined as early nutrition intervention.[13]

Nutritional support can be given through one of three routes:

- Oral—In critically ill patients who are capable of eating, oral diet is the preferred method. If oral intake cannot be started, early enteral nutrition (EN) in adult patients must be commenced rather than delaying it or considering parenteral nutrition (PN).[7]
- Enteral (EN)—feeding *via* a tube directly into gastrointestinal tract.[14]
  - Nasogastric—this is the most common and preferred mode of feeding in the ICU, especially in surgical intensive care units. The insertion of a nasal tube may be associated with malposition, difficulty swallowing or coughing, discomfort, sinusitis, and nasal tissue erosion and is contraindicated in a patient with a base of skull fracture due to the risk of intracranial penetration.
  - Oral tubes—not suitable for awake patients however should be considered in intubated patients to reduce sinusitis which can lead to increased risk of ventilator-associated pneumonia.
  - Enterostomy—gastrostomy or jejunostomy. It can be placed at the time of surgery or as a separate procedure. It may increase the risk of peritonitis. Evidence from non-ICU patients suggests that there are significant benefits for those who require nutritional support for over 4 weeks.
  - Post-pyloric feeding—nasojejunal or jejunostomy. A nasojejunal tube should be over 120 cm long to ensure correct placement.[15] Post-pyloric feeding is recommended for patients at high risk of aspiration, poor intestinal motility, delayed gastric emptying, those undergoing major intra-abdominal surgery, and patients who are intolerant of gastric feeding.[7] Feeding directly into intestine surpasses these issues of gastroparesis. Small bowel ileus is much less common and tends to be less prolonged than gastric ileus; the small bowel recovers normal function 4–8 hours postoperatively.

Situations in which EN should be withheld[7]

- Profound shock,
- Hypoxemia and acidosis,
- Uncontrolled upper GI bleed,
- Gastric aspirate >500 mL/6 hours and bowel ischemia,
- Intestinal obstruction,
- Abdominal compartment syndrome,
- High-output fistula without distal feeding access–here, evaluate possibility of enteroclysis and/or chyme reinfusion,
- Unrepaired anastomotic leak, internal or external fistula, or if distal feeding access is not achieved.

In case of contraindications to oral and EN, early and gradual PN should be initiated within 3–7 days.[7]

- Parenteral: Early and progressive PN is recommended rather than no nutrition in case of contraindications for EN in severely malnourished patients.

  Parenteral nutrition is most often given *via* a central vein as the solutions are usually hypertonic. Preparations for peripheral use are available; however, they have to be isotonic which means that very large volumes would have to be given to provide adequate nutritional support. This severely limits their usefulness.

Monitoring Tolerance of Feeding

ASPEN 2016 guidelines recommend that 500 mL of gastric residual volume (GRV) should be considered tolerable for continuation of feeding.[13] If intolerance is noticed then injection metoclopramide or erythromycin should be given to help gastric emptying. Mc Clave et al., in ASPEN guidelines have recommended that gastric volume should be assessed 8 hourly and 300–500 mL of residual feeds should be considered tolerable in high-risk patients and ventilated patients. They have suggested to give low volume.

Daily Record

Daily assessment of the nutritional status of all the patients started on nutritional supplementation is mandatory by means of weight gain, consciousness levels, and electrolyte levels. A nutritional chart like the one done for children should be done and the patient's initial status and daily data should be recorded. This will not only guide but also serve as a means of learning tool for further improvements.[16]

Immunomodulators

Omega-3 (ω-3) fatty acids, selenium, and antioxidants act as immunity boosters in critically ill patients. All chronically ill and acutely sick traumatic brain injury, and patients with acute respiratory distress syndrome (ARDS) should be given immune-modulating nutrients. There has been a reduction in hospital-acquired infections and hospital stay in patients given glutamine supplementation.[17] Authors Chen and Yang in critical care journal have recommended not to use these in critically ill patients with multiorgan failure.

Nutritional Care According to Various Diseases

Traumatic Brain Injury

Traumatic brain injury (TBI) patients have increased metabolic rate and high catabolism, which leads to loss of muscle mass and loss in weight and so they are prone to malnutrition.[18] These are the patients who should be started with early nutritional supplementation. As soon as they are hemodynamically stable, they should be started with feeds. Arginine-containing immune-modulating formulations or eicosapentenoic acid/docosahexaenoic acid supplement with standard enteral formula in TBI patients is recommended.

Respiratory Disease

Patients with chronic obstructive pulmonary disease (COPD) and respiratory have very lean thin body. They are mostly smokers with less fatty tissue and high metabolic rate.[19] As these patients are most likely candidates for feed intolerance, they should be started with small quantity but frequent feeds to meet their daily requirements.[20] These patients have a high calorie requirement, so calorie-dense enteral formulations should be given for patients with respiratory failure. Serum phosphate levels should be monitored and replaced as when needed.

Acute Kidney Injury

High catabolic rate and protein loss lead to increased morbidity and mortality risk in acute kidney injury (AKI).[21] Also, renal failure patients on continuous renal replacement therapy tend to lose proteins. These patients should not be deprived of proteins. Standard enteral formula has been recommended for ICU patients with AKI. Patients of renal failure mostly have electrolyte imbalances and the frequency increases after starting them on feeds. These electrolyte imbalances give rise to life-threatening arrhythmias. Therefore, electrolytes should be routinely monitored in these patients and supplemented whenever deranged.

Hepatic Failure

Patients with end-stage liver failure and hepatic encephalopathy (HE) are mostly malnourished due to poor dietary intake, altered absorption of nutrients, protein losses, catabolic state, and inflammation. There is no advantage of adding branched-chain amino acid formulations in liver patients with encephalopathy. Proteins should be added. Protein-energy requirements should be done on the basis of their dry weight.[22] Sodium should be restricted in the diet to avoid edema and ascites in these patients. Maximum intake of up to 2 g per day of sodium is recommended in patients with ascites.[23] Enteral nutrition should be preferred in patients with liver failure.

Fallacies of Nutritional Support

As there are advantages, there are several disadvantages of nutritional supplementation. One needs to be aware to remain vigilant about their presentation.

Hyperglycemia

Hyperglycemia is commonly observed in ICU patients after starting them on feeding. Therefore, blood glucose levels should be measured on admission, and then forth hourly. If patients develop hyperglycemia, they should be started on insulin infusion and glucose levels are monitored hourly till strict control is achieved (80–110 mg/dL).

Feeding-related Diarrhea

Diarrhea is commonly observed in critically ill patients. Enteral tube feeding is commonly gives rise to diarrhea. We can reduce the occurrence and treat such feeding-related diarrheas by knowing the constituents of formulae and their effect on gut function.[24] Mixed fiber-containing or soluble fiber-supplemented and small peptide-based semielemental formula feed are used in patients who do not respond to diarrhea.[25] Feeding should not be interrupted if diarrhea happens rather its cause should be evaluated. Probiotic agents are not to be given to critically ill patients as per recommendations from several studies and guidelines.

Refeeding Syndrome

Refeeding syndrome occurs in severely malnourished patients who are started on feeding in the initial days of feeding. They show signs of weakness, respiratory failure, cardiac failure, arrhythmias, seizures, and even death. Prolonged starving loses electrolytes, secondary to leakage, and after availability of carbohydrates, electrolytes enter into the cells, which leads to profound low levels of phosphate, magnesium, potassium, and calcium. To avoid such instance, feeds should be started in 25–50% of energy requirements and gradually increased. The electrolyte levels should be monitored and supplemented. Water soluble vitamins and trace elements should help in early stabilization in such patients.

Overfeeding

Overzealous feeding does not work and is associated with a poor outcome. It leads to uremia, hyperglycemia, hyperlipidemia, fatty liver (hepatic steatosis), hypercapnia (especially with excess carbohydrates), and fluid overload. Whenever inj. propofol (either 1% or 2%) and 10% Intralipid are used for patients, they must be included while calculating total calorie intake.

Specific Complications

Aspiration pneumonia is most common complication seen in patients on enteral feeding. Checking for gastric residual volume prior every next feeds and training the nursing staff regarding strategies to avoid aspiration can prove to be of help in reducing the incidence of aspiration of feeds.

Complications of Parenteral Nutrition

Pneumothorax, hemothorax, infection, central vein thrombosis are commonly seen complications with the use of central venous catheter. Also, the central line if used for giving parenteral nutrition, then should not be used for giving fluids and medications. Sterile precautions must be used when changing bags and the lumen of the central venous line must not be used for blood collection. Parenteral nutrition causes hyperbilirubinemia. Also, care must be taken to avoid electrolyte imbalances and micronutrient deficiencies.

Conclusion

Critically ill patients in the ICU are at significant risk for malnutrition. Feeding protocols not guided by an assessment of REE may result in under- or overfeeding. Emphasis should be placed on early enteral nutrition, and where not achievable, parenteral nutrition should be implemented with careful monitoring of parameters to avoid overfeeding. Exercise can be an important adjuvant therapy to calorie and protein supplementation. As the patient progresses to recovery, efforts to maintain adequate nutritional intake should be continued to prevent undernutrition secondary to dysphagia and poor oral intake. Nutritional support and supplementation tailored to the etiology and recovery stage of ICU patients can improve metabolic condition, decrease morbidity, and optimize long-term rehabilitation success.

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