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Review Article

Medical Nutrition Therapy for the Critically Ill

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ABSTRACT

Nutritional support has been an often neglected but essential and crucial element in management of critically ill. The medical nutrition therapy is fast replacing the concept of supportive nutrition in critically ill patients. Adequate and proper nutrition therapy has the potential to positively impact patient outcomes and length of hospital stay. It is relatively inexpensive compared to other treatments, and is being increasingly identified as a marker of quality ICU care.

Key words: Critically ill, Enteral nutrition, Nutrition, Parenteral nutrition.

INTRODUCTION

Nutritional support is recognized to be as an essential and crucial element in management of critically ill. [1] The importance of nutrition and its availability in the intensive care unit is now improving with an understanding of the pathophysiology of protein energy malnutrition (PEM) of the critically ill patients and the advances in modalities in administration of nutritional therapy. [2,3] Its status has changed over the time from being just an adjunct in critical care to that of a definitive therapy - medical nutrition therapy. The pneumonic given by Vincent, for the caring of patients in an intensive care unit (ICU) also emphasized the importance of feeding - “FAST HUG” (Feeding, Analgesia, Sedation, Thromboembolic prophylaxis, Head end elevation, Ulcer prophylaxis, and Glucose control). [4] It is known that nutrition depletion is associated with increased morbidity and mortality of the patients, and that correction or prevention of this malnutrition can improve the outcome of the patients, especially in critical care and decrease the length of ICU and hospital stay. [4,7]

Nutrition therapy deserves more priority and concern in critically ill patients as there is a high incidence of malnutrition and even the pre-existing malnutrition is aggravated due to the fact that they are in a state of hyper catabolism because of the ongoing inflammatory response, metabolic stress, anorexia and decreased mobility. [5] This has been seen more commonly in geriatric patients.

Nutrition in the intensive care unit:

Patients with critical illness have physiological derangements which results in a significant alteration in their metabolism of essential nutrients - elevated levels of glucagon, cortisol, insulin and catecholamines. Inflammatory cytokines TNFa and IL-6 and bacterial endotoxin also alter glucose utilization and enhance protein catabolism.

This results from various factors, namely: the disease itself - diabetes, sepsis or pancreatitis; physiological stress of the severe illness - sepsis, burns, polytrauma; derangement of organ function - hepatic or renal failure.

A significant number of critical patients also have altered appetite (anorexia); gastrointestinal tract dysfunction –impaired motility, absorption or digestion; depression; therapeutic restrictions. They all aggravate the problem of malnutrition.

Malnutrition is a state in which a deficiency, excess or imbalance of energy, protein and other nutrients causes adverse effects on body form, function and clinical outcome.

Malnutrition in the ICU patients is associated with muscle weakness (including weak respiratory muscles leading to prolonged ventilation or ventilator dependence or pulmonary aspiration), impaired immune function leading to increased risk of infections, impaired wound healing, and prolonged time to convalesce. [6]

Causes of malnutrition in critically ill commonly seen:

A) Increased nutritional requirement/ deficient nutrient intake: seen in sepsis, trauma, burns, chronic alcoholism, poor socioeconomic condition

B) Impaired nutrition absorption: seen in diarrhea, malabsorption syndrome, gut pathologies, acute pancreatitis, inflammatory bowel disease

C) Increased nutrient losses: seen in malabsorption, diarrheal diseases, enterocutaneous fistulae, short bowel syndromes

D) Co-morbid diseases: diabetes, renal impairment, liver impairment, obesity, metabolic syndrome

E) Other causes: geriatric or pediatric patients, prolonged illness, oncological patients, long term antacid and diuretic use.

Various studies have shown that the prevalence of malnutrition is particularly high in at risk elderly patients, especially with impaired mental and cognitive function, [7,8] also associated with higher prevalence of co-morbid diseases related to respiratory, cardiac, hepatic, renal, and other body organs. The presence of protein energy malnutrition in elderly and critically ill patients is an important independent determinant for higher morbidity and mortality [9-12]

Goals of nutrition support in the ICU [13] :

Medical nutritional support in critically ill helps to provide support to the patient undergoing adaptive changes which occur due to starvation and as part of the stress response during illness or injury and is directed to conserve body proteins and maintaining of normoglycaemia, while ensuring that the body is prepared to fight infection and undergo subsequent healing processes.

Goals of nutrition support:-

1. Detect pre-existing malnutrition and provide nutrition based on the patient's medical condition and the available route of administration
2. Prevent deficiency related morbidity and further depletion of nutrients
3. Provide adequate energy requirements, adequate nutrients and preserve lean body mass
4. Maintain body's defense and immune functions

5. Manage fluid and electrolyte balance and avoid metabolic complications

Nutritional status assessment:

Screening tools for nutrition assessment are [14]:-

1. Malnutrition Universal Screening Tool (MUST)
2. Subjective Global Assessment (SGA)
3. Mini Nutritional Assessment (MNA)
4. Malnutrition Screening Tool (MST)
5. Nutritional Risks Screening 2002 (NRS-2002)
6. Nutrition Risk Index (NRI)
7. Short Nutritional Assessment Questionnaire (SNAQ)

MUST is a widely used screening tool which uses five step assessment to identify patients who are malnourished, at risk of malnourishment or obese. [15]

The risk factors associated with malnutrition are:-

1. Underweight patients -body mass index < 18.5kg/m^2
2. Unintentional weight loss of > 10% within the last 3-6 months or > 5% in last one month
3. Patients with poor intake for more than 5 days or likely to have poor or no oral intake for the next 5 days or longer
4. Patients having protracted nutrient losses due to the presence of a fistula, abscess, or wound; hyper-catabolic states; poor absorptive capacity of the gut.
5. History of alcohol abuse, use of drugs with catabolic properties.
6. Impoverishment, isolation, and advanced age.

Nutritional status is done by:-

1) Physical and clinical examination

The clinical assessment includes examination for any signs of nutrient deficiency, hydration status, edema, hemodynamic status, body temperature, and functioning of the gastrointestinal tract.

The gross indicator of nutritional deficit is the loss of body weight, which can be assessed using the body mass index (BMI) as:

Body Mass Index (BMI): Weight (kg)/height^2 (cm).

Malnutrition is often associated with gross edema and ascites. Thus, accurate weight estimation is usually not possible limiting its use in critically ill patients. Unintentional weight loss of more than 10% within the last six months has been found to correlate well with clinical outcome. [16,17]

Anthropometric measurement- skin-fold thickness is useful for estimating body fat stores due to the fact that 50% of body fat is present in the sub-cutaneous region. Skin-fold thickness also allows discrimination of fat from muscle mass. Triceps skin fold (TSF) thickness generally represents the body's overall fat. A TSF thickness < 3 mm suggests exhaustion of fat stores.

2) Biochemical parameters

These include measurement of serum albumin, prealbumin, transferrin, and retinol-binding protein. The serum albumin concentration is considered to be a better indicator of metabolic stress or injury and a poor indicator of nutritional status due to a compensatory decrease in its production by the liver in response to systemic stress of critical illness and an increase in production of acute phase proteins. [18]

Calculation of substrate requirements

The total fluid requirement is estimated to be around 30 to 40 ml/kg/day or 1 ml of water per calories in an adult. The requirement increases in cases of excessive fluid losses, which can be divided into overt losses (excessive upper gastrointestinal losses, diarrhea, or polyuria) and insensible or evaporative losses. The excessive insensible losses are usually as a result of on-going pyrexia, tachypnea, or excessive sweating.

The estimated addition of fluid is 2.5ml/kg/day for each degree rise of temperature above 37^{o}C.

Calorie requirements:

The daily caloric requirements or the basal energy expenditure (BEE) is calculated by measuring the basal metabolic rate using the Harris Benedict Equation:

For Males:

BEE (kilocalories/day) = 13.75 × weight (kg) + 5 × height (cm) – 6.78 × Age (yrs) + 66

For Females:

BEE (kilocalories/day) = 9.56 × weight (kg) + 1.85 × height (cm) – 4.68 × Age (yrs) + 655

In a healthy, afebrile individual it is estimated around 25 kcal/kg/day and has to be modified accordingly.

BEE is multiplied by 1.2 to allow for the thermal effect of food. Adjustments in BEE are made as follows:-

1. Fever - BEE x 1.1 (for each 1°C above 37^{o}C)
2. Mild stress - BEE x 1.2
3. Moderate stress - BEE x 1.4
4. Severe stress - BEE x 1.6
5. Sepsis increases BEE by 9%, regardless of temperature
6. Burns increases BEE by 100% if surface area involved is more than 30%

These estimated calories can be supplemented in three forms:

a) Carbohydrates - They should provide approximately 50-70% of caloric requirements. One gram of carbohydrate provides about 3.75kcal of energy.

b) Proteins - They should provide 15-20% of caloric requirements. Protein requirements are higher than normal in critically ill patients due to hyper catabolic state.

Protein requirement = 1.5 to 2.0 g/kg/day. [19]

c) Lipids/Fats - 20-50% of daily energy requirement should be provided by lipids. Polyunsaturated fatty acids (PUFA) should be included to provide the essential fatty acids. One gram of fat provides about 9.3 kcal of energy.

d) Micronutrients: These include electrolytes such as sodium and potassium which are required at 1 mmol/kg/day (increased requirements in excessive gastrointestinal losses and increased sweating). Other essential micronutrients required in smaller amounts include magnesium, phosphorus, iron, zinc, and selenium, which are important in maintaining normal homeostasis.

Types of nutritional support

1. Enteral - Enteral nutrition is feeding via a tube placed in the gut to deliver liquid formulas containing the essential nutrients, both macro and micro nutrients.

2. Parenteral - It is the infusion of complete nutrient solutions into the blood stream via peripheral/central venous access to meet nutritional needs of the patient.

1. Enteral nutrition

Enteral nutrition is the preferred route of feeding as it maintains the functional and also structural integrity of the gut which, if not maintained can lead to translocation of bacteria causing peritonitis and septicemia. It also maintains the structural integrity of the GI tract by maintaining a height of villi and supporting the mass of secretory IgA producing immune cells of gut associated lymphoid tissue. [20]

Modes of enteral nutrition

1. Nasogastric (NG): The most common route used in intensive care. Here a feeding tube in inserted into the stomach through the nostrils. Complications include malposition, nasal tissue erosion, sinusitis and is contraindicated in the patients with fracture of base of skull.

2. Orogastric: This route is used when NG is contraindicated, and to prevent sinusitis. It is tolerated well by the sedated patients, but not in awake patients.

3. Nasojejunal (NJ) or Post pyloric: The feeding tube is placed in jejunum bypassing the stomach. This prevents the risk of aspiration.

4. Enterostomy: Includes gastrostomy or jejunostomy- here feeding tube is inserted directly into the stomach or jejunum either endoscopically or surgically and brought out through the peritoneal cavity. Complications include displacement or infection. It is often preferred in patients requiring nutritional support for more than a month.

Indication for enteral nutrition

If the patient has an inadequate or no oral intake of food for 1 - 3 days, then nutritional support by the enteral route is required.

The types of enteral feeds:

Standard enteral nutrition: This type of feed is isotonic to serum with a Caloric density of approximately 1 kcal/mL. They are prepared lactose-free with intact (non hydrolyzed) protein content of about 40 g/1000 mL (40 g/1000 kcal) and non protein calorie to nitrogen ratio of approximately 130. There is a mixture of simple and complex carbohydrates along with long-chain fatty acids (although sometimes medium-chain and omega-3 fatty acids are included) and also essential vitamins, minerals, and micronutrients.

Concentrated enteral feeds: Frequently the critical patients require volume restriction thus concentrated enteral feeds may be used. These feeds have a similar composition as of standard feed, except that it is mildly hyperosmolar to serum and has a caloric density of 1.2, 1.5, or 2.0 kcal/mL. The hyperosmolar concentrated enteral nutrition predisposes patients to diarrhea or symptoms similar to dumping syndrome if infused rapidly. Dumping syndrome is characterized by symptoms of nausea, shivering, diaphoresis, and diarrhea shortly after eating foods containing high amounts of refined sugars.

Predigested feeds: Also known as chemically defined, semi-elemental, or elemental feeds, differ from standard enteral nutrition in that the various macronutrients are provided in a readily and easily absorbable form, like proteins as peptides or amino acids, lipids as medium chain triglycerides, and carbohydrates as mono or disaccharides. Predigested enteral nutrition may be beneficial in patients who do not tolerate the standard enteral nutrition or have malabsorption syndrome. They are also useful in few conditions like thoracic duct leaks, chylothorax, or chylous ascites, since the medium-chain triglycerides do not enter the lymphatic capillaries in the small intestine.

Predigested enteral feeds have a caloric density of 1 or 1.5 kcal/mL and may be used as an initial tube feed in patients with marginal gut function or a short gut as they are believed to be better tolerated.

<u>Recommendations for enteral nutrition (EN):</u>

1. Enteral nutrition should be initiated early (within 24-48 hours) as delay in feeding has been associated with higher incidence of gut permeability and release of inflammatory cytokines. [21]

2. In patients who are hemodynamically unstable (require high doses of vasopressor or inotropic support and/or large volume blood product or fluid resuscitation), EN should be kept on hold until patients are fully resuscitated and stable. [22]

In such settings EN is known to precipitate subclinical bowel ischemia / reperfusion injury involving the intestinal microcirculation. Bowel ischemia is a rare complication of EN, occurring in <1% of cases, but related mortality rate is high. [22]

3. Feeding should be gradually advanced towards the minimum goal of achieving >50-65% of the target calories over next 48-72 hours. [22]

4. If unable to meet energy requirements (100% of target goal calories) after 7-10 days of enteral route alone, initiation of supplemental parenteral nutrition should be considered.

5. Permissive Underfeeding or hypocaloric feeding is recommended for critically ill obese patients (BMI >30) with the goal of EN regimen being not to exceed 60-70% of target energy requirements or 11-14 Kcal/Kg actual body weight. [21]

Feeding regimen

Ryles tube feedings are infused for 12 - 16 hours in each 24 hour period. Gastric retention should be monitored in the patient. If 4-hour gastric residual volume (GRV) is less than 200 ml, gastric feeding can be continued. [23,24] A recent study [25] reported that not measuring GRV in medical ICU patients was associated with an increase in nutritional intake without additional risk of aspiration pneumonia.

An elevation of the backrest to levels between 30° - 45° has a protective effect against aspiration with use of a gradual infusion of feeds. Also, using erythromycin and metoclopramide as prokinetic agents in combination is more effective than either agent alone in improving the outcomes of enteral nutrition. [23]

Complications of enteral feeding

A) Aspiration – Important and the most common complication.

c) Diarrhoea

d) Refeeding syndrome. [26]:- Refeeding syndrome is seen in patients with chronic malnutrition or poor oral intake for more than 5 days, in whom full nutritional requirement is suddenly initiated. It occurs when feed containing adequate calories is initiated in these patients, there is an insulin release, causing intracellular shift of phosphate, potassium, magnesium and thiamine. It is characterized by hypokalemia, hypomagnesaemia and hypophosphatemia. This may result in cardiovascular abnormalities like ventricular arrhythmias, left ventricular failure, pulmonary edema and hypotension along with respiratory muscle weakness. Other manifestations include confusion, Wernicke's encephalopathy, seizures, paresthesia and tetany due to thiamine deficiency and electrolyte imbalance and also diarrhea and lactic acidosis. Sodium retention due to insulin release may cause peripheral and/or pulmonary edema. Patients who have poor oral intake for more than 5 days should be started on nutritional support at about 50% of their requirement for the first 2 days. Feeding can be started at 10 kcal/kg/day and rates can be increased gradually to reach energy targets over 4 - 7days.

e) Feed Intolerance: This can occur in patients with diabetes, renal failure, sepsis, and in patients on drugs like opioid analgesics and anti-cholinergic agents.

2. Parenteral nutrition (PN)

Indications for parenteral nutrition

A) Previously healthy patient with no malnutrition at the time of admission and enteral nutrition not feasible:- PN to be initiated after 7 days of admission.

B) Malnourished patient on admission and enteral route not feasible:- PN to be initiated immediately.

C) Major upper gastrointestinal surgery and enteral nutrition not possible:- PN to be initiated as soon as possible. PN can even be started pre-operatively in malnourished patients.

Parenteral nutrition formulations: Available as carbohydrates and amino acid solutions and also along with lipids. Separate lipid formulations are also available as 10% or 20% emulsions, which have a caloric value of 1 Kcal/ml and 2 Kcal/ml respectively. The best parenteral nutrition or the total parenteral nutrition is provided as an all-in-one bag containing water, dextrose, amino acids, lipids, vitamins and trace elements.

Complications of parenteral feeding

a) Catheter related:- Infections, procedure complication during the central catheter insertion

b) Carbohydrate infusion related:- Hyperglycemia, hypophosphatemia, and fatty liver

c) Lipid infusion related:- Oxidation induced cell injury

d) Gastrointestinal complications:- Mucosal atrophy and acalculous cholecystitis

e) Metabolic complications:- Electrolyte disturbances, acid-base disorders, liver dysfunction, and trace element or essential fatty acid deficiency.

Immunonutrition

Critical illness is characterized by immune dysfunction, which along with malnutrition, oxidative stress and inflammation cause cellular damage and impairs function of vital organs. Feeding formulas with specific immunonutrients can help in enhancing immune function and thus controlling inflammation and decreasing tissue damage but not routinely advised.

Dietary anti-oxidants (vitamin E, beta carotene) stabilize free radicals in cells and decrease oxidative injury. Dietary fish oil helps to decrease inflammatory responses by modulating the synthesis of pro- and anti-inflammatory mediators.

a) Arginine [27] - An amino acid, which plays an important role in various metabolic processes like urea cycle, lymphocyte proliferation, and also an important factor in wound healing.

It is also thought to modulate blood flow through its role in nitric oxide production and thus given to post-operative patients have found to be beneficial.

b) Glutamine [28-30] - The most abundant amino acid which is an integral part of glutathione, an antioxidant. It is also considered to be a metabolic substrate for enterocytes and immune cells and supports intestinal barrier function and immune responses. It gets depleted from the muscle stores during severe metabolic stress like sepsis and major surgery. In some studies glutamine substitution has been shown to decrease the rate of infection, inflammation and thus decreases the hospital stay and mortality [30]

c) Prebiotics - They are non-digestible food ingredients that stimulate the growth of beneficial bacteria in the GI tract.

d) Omega-3 polyunsaturated fatty acids also have been shown to act as an immunomodulator as well as an anti-inflammatory agent when added to the nutrition.

e) Probiotics - They are micro-organisms of human origin which when administered in an adequate amount give a health benefit to the host.

f) Gut hormones [31] - During the early phase of critical illness the fasting Ghrelin concentration is reduced. Exogenous Ghrelin provides a potential therapy that can be used to accelerate gastric emptying and/or stimulate appetite. Hormones like Cholecystokinin and Peptide YY increase the gastric emptying time. Therapies with incretin still need further evaluation for managing the hyperglycemia in the critically ill.

Nutrition support in special cases

Sepsis

Sepsis is characterized by a severe catabolic state which requires an extra 10–20% increase in total calorie requirement and also high requirement of proteins due to its accelerated breakdown. There are increasing requirements of electrolyte and trace elements with close monitoring. Hyperglycemia is a common finding and may require insulin infusion.

Deranged hepatic functions

Hepatic failure patients commonly develop severe electrolyte abnormalities such as hyponatremia, hypokalemia, and hypomagnesemia and should be taken care of by adequate and proper nutrition. These patients usually have edema with the presence of ascites, so fluid restriction is employed to prevent formation of further ascites.

Acute hepatic failure also results in elevation of serum ammonia levels due to defective urea cycle leading to encephalopathy. Thus, these patients require restriction of certain amino acids which are replaced with branched chain and aromatic amino acids.

Acute renal failure

Patients with acute renal failure do not require protein restriction. As most these patients are oliguric, calorie dense formulae are required to provide adequate calories without causing fluid overload. Potassium restriction may be needed and other electrolytes like magnesium and phosphate are supplemented with precaution and with frequent monitoring. Protein requirements may be as high as 2.5g/kg/day if the patient is receiving dialysis or continuous renal replacement therapy.

Acute Pancreatitis

In acute pancreatitis, enteral feeding through a nasogastric tube should be attempted as soon as fluid resuscitation is complete. Feeding is initiated within 24 to 48 hours and gradually increased over the next few days.

CONCLUSIONS

Nutrition is an important and often neglected or overlooked aspect of managing a critically ill patient. Malnutrition and under-nutrition is a common complication in critically ill patients and is associated with a poor outcome. Over the last few years the concept of nutrition has changed from just providing the normal daily nutritional support to a protocolized medical nutrition therapy by a registered dietician along with the treating intensivist which can alter the course and outcome of the patient to a better response.

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