Nutrition in critically ill patients

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Abstract

Malnutrition is a persistent problem in hospitals and intensive care units (ICUs) worldwide. The concept of therapeutic nutrition has replaced supportive nutrition in critically ill patients. Iso-energetic feeding improves outcome in ICU patients. Ideally, enteral nutrition should be initiated as early as possible and pro-kinetic agents can be used to improve gastric tolerance in critically ill patients. If enteral nutrition is not feasible, parenteral nutrition can be given to optimise the patient’s energy requirements. Parenteral nutrition needs specialised care and monitoring. Newer pharmaconutrients and gut hormones are available, but further studies are needed before their routine use can be recommended.

Key words: Enteral nutrition, parenteral nutrition, pharmaconutrients.

Introduction

Critically ill patients quickly develop malnutrition, or pre-existing malnutrition is aggravated due to the inflammatory response, metabolic stress and bed rest which cause catabolism. This response is combined with complications of increased morbidity due to infection, multi-organ dysfunction (MOD) and prolonged hospitalisation.

The persistence of this problem – despite existing guidelines – is partly explained by the absence of immediately visible consequences of acute malnutrition. 15 - 70% of patients admitted in hospitals are malnourished. Malnutrition remains undiagnosed in 70% of hospitalised patients, and among these, 70 - 80% patients do not receive any nutritional support in the hospital.

Importance of nutrition in the intensive care unit

Approximately 60% of intensive care unit (ICU) patients suffer from gut dysfunction due to impairment in gastrointestinal (GI) motility, digestion, or absorption. GI dysfunction along with inadequate intake of calories leads critically ill patients to develop an energy deficit and lose lean body mass.

Malnourished ICU patients experience immune dysfunction, weakened respiratory muscles, lowered ventilation capacity and reduced GI tolerance. Hence, they are at risk of developing complications like ventilator dependence, gastro-oesophageal reflux, pulmonary aspiration, and infections that can lead to sepsis, multi-organ failure, and even death.

Goals of nutrition in the ICU

Nutritional support in critically ill patients was considered as an adjunctive care to provide exogenous fuels to support the patient during the period of stress. This support had 3 main goals:-
1. To preserve the lean body mass.
2. To maintain the immune function.
3. To avoid metabolic complications.

Feeding an ICU patient now extends beyond choosing the right feeding route, the rate and the caloric density. In modern critical care, the concept of ‘therapeutic nutrition’ is replacing traditional ‘supportive nutrition’.

Assessment of nutritional status of a patient

Patients at risk for developing malnutrition are:-
1. Underweight patients (body mass index < 18.5) and/or a recent loss of > 10% of usual body weight.
2. Patients with poor intake for more than 5 days.
3. Patients having protracted nutrient losses due to the presence of fistula, abscess, or wound.
4. Hyper-metabolic states.
5. History of alcohol abuse, use of drugs with catabolic properties.
6. Impoverishment, isolation, and advanced age.

Screening Tools for assessment of nutrition are:-
1. Malnutrition Universal Screening Tool (MUST)
2. Subjective Global Assessment (SGA)
3. Mini Nutritional Assessment (MNA)
4. Malnutrition Screening Tool (MST)

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Assessment of nutritional status is done by:-

1. **Physical examination**

Weight, height and body mass index (BMI) are assessed along with examination for signs of any nutrient deficiency. Unintentional weight loss during illness often reflects loss of lean body mass.

Measurement of skin-fold thickness is useful for estimating body fat stores, because 50% of body fat is normally present in the sub-cutaneous region. Skinfold thickness also permits discrimination of fat from muscle mass. Triceps skin fold (TSF) thickness is generally representative of the body’s overall fat. A TSF thickness < 3 mm suggests exhaustion of fat stores.

2. **Biochemical tests**

Albumin, transferrin, pre-albumin and retinol-binding protein (RBP) are negative acute phase proteins. C-reactive protein (CRP) and ceruloplasmin are positive acute phase proteins.

Nitrogen balance assessment is the only biochemical parameter that truly reflects visceral and somatic protein pools.

**Calculation of substrate requirements**

The total intake of prescribed nutritional support should account for:-

1. Energy, protein, mineral, micro-nutrients, fibre, and fluid and electrolyte needs.
2. Levels of activity and the patient’s underlying clinical condition.
3. Gastro-intestinal tolerance, potential metabolic instability, and risk of re-feeding problems.
4. The likely duration of nutritional support.

**Energy requirements**

The energy requirement of a patient is not static and keeps changing during the course of ICU stay. Measurement of resting energy expenditure by indirect calorimetry is the gold standard. But, this involves specialised expensive equipment, trained personnel, and cannot be measured in certain settings. For example, O₂ sensor is not reliable at FiO₂ > 50% (FiO₂ - fraction of inspired oxygen).

Energy expenditure is measured from the volume of O₂ (VO₂) consumed, and the volume of CO₂ (VCO₂) produced. Resting energy expenditure (REE) is calculated by the Weir formula as given below:-

\[
REE \text{ (kcal/day)} = \left( (3.9 \times VO_2) + (1.1 \times VCO_2) - 61 \right) \times 1440
\]

**Basal energy expenditure (BEE)**

Daily energy expenditure is expressed as BEE. BEE is defined as heat production by basal metabolism in the resting and fasting states.

Simple equation for BEE (kcal/day) = 25 x body weight in kilograms.

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 normal body temperature)
2. Mild stress — BEE x 1.2
3. Moderate stress — BEE x 1.4
4. Severe stress — BEE x 1.6

Harris Benedict equation can also be used to calculate BEE:-

1. Males — BEE = 66.47 + (13.75 x weight) + (5 x height) – (6.76 x Age)
2. Females — BEE = 655.1 + (9.56 x weight) + (1.8 x height) – (4.68 x Age)

BEE — In kilocalories/day
Weight — In kilograms
Height — In inches
Age — In years

**Substrates**

a) Carbohydrates — They should provide approximately 70% of caloric requirements.

b) Proteins — Protein requirements are higher than normal in critically ill patients due to hypercatabolism.

Protein requirement = 1.2 to 1.6 g/kg/day.

c) Lipids — 30% of daily energy requirement should be provided by lipids.

d) Fluids — Fluid requirement is estimated to be 30 ml/kg of body weight + replacement for abnormal losses.

But, this also depends on the patient’s underlying clinical condition and has to be individualised.

e) Vitamins
Table I: Requirement of vitamins in critically ill patients.

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Enteral dose</th>
<th>Parenteral dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin A</td>
<td>1,000 µg</td>
<td>3,300 IU</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
<td>3 µg</td>
<td>5 µg</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>60 mg</td>
<td>100 mg</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>5 µg</td>
<td>200 IU</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>10 mg</td>
<td>10 IU</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>100 µg</td>
<td>10 mg</td>
</tr>
<tr>
<td>Thiamine</td>
<td>2 mg</td>
<td>3 mg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>2 mg</td>
<td>4 mg</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>2 mg</td>
<td>4 mg</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>6 mg</td>
<td>15 mg</td>
</tr>
<tr>
<td>Biotin</td>
<td>150 µg</td>
<td>60 µg</td>
</tr>
<tr>
<td>Folic acid</td>
<td>400 µg</td>
<td>400 µg</td>
</tr>
</tbody>
</table>

µg = microgram; mg = milligram; IU = international units

Hypo-caloric feeds

They have the potential to provide nutritional support without increasing the stress response. Permissive hypo-caloric feeds are recommended in critically ill obese patients.

Large energy deficits are associated with poor patient outcome. The cut-off for the appearance of biological consequences of under-feeding was found to be between –50 and –60 kcal/kg body weight.

Types of nutritional support

1. Enteral – Enteral nutrition is feeding via a tube placed in the gut to deliver liquid formulas containing all essential nutrients.
2. Parenteral – It is 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 supports the functional integrity of the gut by maintaining tight junctions between the intra-epithelial cells, stimulating blood flow and inducing the release of trophic endogenous agents. It also maintains the structural integrity of the GI tract by maintaining height of villi and supporting the mass of secretory IgA producing immune cells of gut-associated lymphoid tissue (GALT).

Enteral nutrition is the preferred route of feeding for the critically ill patient who requires nutritional support. Compared to parenteral nutrition, infectious morbidity is reduced with enteral nutrition along with reduction in hospital stay and reduced cost of hospitalisation.

Modes of enteral nutrition

1. Nasogastric (NG)
2. Nasojejunal (NJ)
3. Percutaneous endoscopic gastrostomy (PEG)
4. Percutaneous endoscopic jejunostomy (PEJ)
5. Radiologically inserted gastrostomy (RIG)
6. Surgical gastrostomy
7. Surgical jejunostomy

Indication for enteral nutrition

If the patient has an inadequate oral intake for 1 - 3 days, it calls for nutritional support by the enteral route.

Contra-indications for enteral nutrition

1. Circulatory shock
2. Complete mechanical bowel obstruction
3. Severe diarrhoea
4. Entero-cutaneous fistulas

Composition of enteral feeds

1. Caloric density: 1 - 2 kilocalories/litre of feeding solution
2. Osmolality: 280 - 1,100 mOsm/kg H₂O
3. Proteins: 35 - 40 grams/litre of feeding solution
4. Lipids: They consist of long-chain triglycerides derived from vegetable oils
5. Fibre

Efforts should be made to provide 50 - 65% of the goal calories in order to achieve the clinical benefit of enteral nutrition during the first week of hospitalisation. Enteral nutrition should be initiated as soon as the patient is resuscitated and haemodynamically stable. However, this should not translate into force feeding a patient.

Feeding regimen

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.

An elevation of the back-rest to levels between 40° - 45° has a protective effect against aspiration. Also, using erythromycin and metoclopramide in combination is more effective than either agent alone in improving the outcomes of enteral nutrition.
Glycaemic control

Aggressive glycaemic control (random blood sugar between 81 - 108 mg%) was initially found to be associated with a significant reduction in ventilatory support. This view has been contradicted by the NICE SUGAR study that demonstrated an increase in 90-day mortality with strict blood glucose control.

Complications of enteral feeding

a) Tube occlusion
b) Aspiration
c) Diarrhoea
d) Refeeding syndrome:
Refeeding syndrome refers to severe fluid and electrolyte shifts and related metabolic complications in malnourished patients undergoing enteral nutrition. This occurs due to insulin causing intracellular uptake of glucose and other electrolytes and is characterised by hypokalaemia, hypophosphataemia and hypomagnesaemia.

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 - 7 days.

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

Indications for parenteral nutrition

a) Short-term (< 14 days)
   - Severe pancreatitis
   - Post-chemotherapy mucositis
   - Entero-cutaneous fistula
   - Intractable vomiting
b) Long-term (> 30 days)
   - Inflammatory bowel disease
   - Radiation enteritis
   - Chronic malabsorption

Intravenous nutrient solutions

a) Dextrose solutions:
   These are used for meeting the caloric requirements of the patient. Dextrose, being hyper-osmolar should be preferably given through a central venous line.

b) Amino acid solutions:
   These consist of 50% essential and 50% non-essential and semi-essential amino acids.

c) Lipid emulsions:
   These contain droplets of cholesterol and phospholipids surrounding a core of long-chain triglycerides. These emulsions can be given through a peripheral vein.

d) Electrolytes, minerals, and trace elements.

Complications of parenteral feeding

a) Catheter-related infections
b) Carbohydrate infusion-related: Hyperglycaemia, hypophosphataemia, and fatty liver
c) Lipid infusion-related: Oxidation induced cell injury
d) GI complications: Mucosal atrophy and acalculous cholecystitis

Table II: Monitoring of patients on parenteral nutrition.

<table>
<thead>
<tr>
<th>Laboratory parameter</th>
<th>Frequency of Investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renal function test and serum electrolytes</td>
<td>Daily until patient becomes stable, then 1 - 2 times/week</td>
</tr>
<tr>
<td>Blood glucose</td>
<td>1 - 2 times/day until patient becomes stable, then weekly</td>
</tr>
<tr>
<td>Magnesium and phosphorous</td>
<td>Daily followed by 3 times/week until patient becomes stable then weekly</td>
</tr>
<tr>
<td>Liver function test with PT/INR</td>
<td>Twice weekly until patient becomes then stable, weekly</td>
</tr>
<tr>
<td>Calcium and albumin</td>
<td>Weekly</td>
</tr>
<tr>
<td>Haemogram</td>
<td>1 - 2 times/week until patient becomes stable, then weekly</td>
</tr>
<tr>
<td>Iron and ferritin</td>
<td>3 - 6 monthly</td>
</tr>
<tr>
<td>Folate and vitamin B₁₂</td>
<td>2 - 4 weekly</td>
</tr>
<tr>
<td>C-reactive protein</td>
<td>2 - 3 times/week till patient becomes stable</td>
</tr>
</tbody>
</table>

Pharmaconutrients

Critical illness is characterised by oxidative stress and inflammation, both of which cause cellular damage and impair function of vital organs. Feeding formulas with specific pharmaconutrients can help in controlling inflammation and decreasing tissue damage.

Dietary anti-oxidants stabilise free radicals in cells and decrease oxidative injury. Dietary fish oil and borage oil blunt inflammatory responses by modulating the synthesis of pro- and anti-inflammatory mediators.

a) Arginine supplemented enteral formulas – They are used in the peri-operative period.
b) Glutamine – It is a metabolic substrate for enterocytes
and immune cells and supports intestinal barrier function and immune responses.

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

d) Probiotics – They are micro-organisms of human origin which when administered in adequate amounts confer a health benefit to the host.

e) Gut hormones\textsuperscript{12} – Fasting Ghrelin concentration is reduced in the early phase of critical illness. Exogenous Ghrelin is a potential therapy that could be used to accelerate gastric emptying and/or stimulate appetite.

Hormones like Cholecystokinin and Peptide YY increase the gastric emptying time.

Incretin therapies need further evaluation in the management of hyperglycaemia in the critically ill.

References


