Nutrition in the Critically Ill Patient

Critically ill patients have severely deranged physiology which results in a significant alteration in their metabolism of essential nutrients. These may result from the illness itself as seen in diabetes, sepsis or pancreatitis, or physiological stress due to severe illness as in sepsis, burns, polytrauma, or due to derangement of organ function as in hepatic or renal failure. Moreover, a significant number of critically ill patients also have alteration in appetite and the function of the gastrointestinal tract. Consequently, studies have revealed that underfeeding occurs in up to 30% of hospitalized and as many as 50% of ICU patients. Inadequate nutrition may alter immune responses, integrity of the gut mucosal barrier, protein synthesis and wound healing, thereby contributing to significant morbidity and mortality. Therefore nutrition is as important a part of treatment of a critically ill patient as are drugs and organ support. Up until a few years ago, the concept of nutrition in the ICU patient was thought of as one of nutritional support, where the main objective was to provide adequate calories and protein to maintain normal body structure and weight during the catabolic phase of the illness. More recently, this concept has been replaced by one of nutritional therapy, where the aim is to modify the contents of the diet in an attempting to attenuate the metabolic response to stress, to prevent oxidative cellular injury, and to favorably modulate immune response. These may be expected to

1. Preserve muscle mass and decrease autocannibalism (use of amino acids for calories)
2. Decrease infection and improve wound healing
3. Maintain gut barrier functions and supporting immune, renal, hepatic, muscle function
4. Reduce ICU length of stay, reduce morbidity and mortality and decrease cost of healthcare.

Most critically ill patients have increased energy and protein requirements as a result of the hypercatabolic or “lytic state” (glycolytic, proteolytic, lipolytic) state. They may also have a tendency to develop hypo- or hyperglycemia, either of which can adversely affect outcomes. The common physiological derangements contributing to these include elevated levels of cortisol, glucagon, catecholamines and insulin. Inflammatory cytokines TNFα and IL-6 and bacterial endotoxin alter glucose utilization and enhance protein catabolism. Organ dysfunction like acute hepatic failure and altered gastrointestinal function can further worsen metabolic disturbances in critical illness. It is therefore evident that in normal healthy individuals, the hormonal response of the body adapts to intermittent feeding and can appropriately respond to changes in the dietary content. However, in critically ill patients, this adaptability is lost and nutrition has to be provided on a continuous basis and its content modified to match the metabolic and hormonal state of the body.

In 2009, comprehensive guidelines on nutrition in the critically ill adult patients have been suggested by the American Society of Enteral and Parenteral Nutrition (A.S.P.E.N), Society of Critical Care Medicine (S.C.C.M) and the Canadian group. The present review is based mainly on these recommendations.

Assessment of Nutritional Status

In critically ill patients, the commonly used anthropometric or biochemical parameters of nutritional assessment are not helpful as edema may mask weight loss and hypoproteinemia is commonly due
Table 1: Indications for use of parenteral nutrition in critically ill patients

<table>
<thead>
<tr>
<th>1. Previously healthy patient, no protein-calorie malnutrition on admission</th>
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<tbody>
<tr>
<td>1. Early EN is not feasible</td>
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<tr>
<td>2. Unable to reach 100% of feeding goal by Day 7</td>
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<table>
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<th>2. Protein-calorie malnutrition on admission</th>
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<tr>
<td>1. EN is not feasible</td>
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<table>
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<tr>
<th>3. Major upper GI surgery, EN is not feasible</th>
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<tbody>
<tr>
<td>1. Malnourished patient</td>
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<tr>
<td>2. Previously healthy patient, no malnutrition</td>
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Note: PN = parenteral nutrition, EN = enteral nutrition

Parenteral nutrition should be initiated only under very specific situations. Typically, it should be reserved only for patients who cannot be fed enterally, and is deferred for at least 5-7 days in those patients who are not malnourished to start.

ROUTE

Enteral feeding is the preferred mode feeding unless there are specific contra-indications. Enteral feeding is associated with significantly lower morbidity and mortality in ICU patients by preserving integrity of the gut mucosa, which derives up to 70% of its nutrition from the luminal contents. Enteral feeding also stimulates splanchnic blood flow and neuronal activity, promotes release of protective IgA and induces secretion of gut hormones that promote trophic activity in the intestinal mucosa. Enteral tube feeds may be delivered in the stomach in most patients. Feeding via a tube placed in the small bowel (post-pyloric site) is preferred in patients at high risk for aspiration or those with intolerance to gastric feeding. Ileus, absence of bowel sounds or passage of flatus is not a contraindication to enteral feeding; continuous post-pyloric feeding may be better tolerated by these patients. Common contraindications for enteral nutrition are severe prolonged ileus, intestinal obstruction and severe hemorrhagic pancreatitis.

Parenteral is expensive, associated with significant complications, and should only be used when specific indications are present (Table 1). Parenteral nutrition in the ICU is almost always administered via a central venous catheter; one lumen of the multi-lumen catheter is reserved.
only for parenteral nutrition to avoid contamination and issues of incompatibility of mixtures. Nutrition may be provided via peripheral venous cannulae and peripheral inserted central catheters in non-ICU patients.

**COMPLICATIONS**

Complications common to all modalities and routes of nutrition are fluid overload, hyperglycemia, underfeeding and the refeeding syndrome. Fluid overload is common in patients with oliguric renal failure or heart failure. Hyperglycemia is seen in about 27% of ICU patients and may be due to pre-existing diabetes or the systemic inflammatory response syndrome resulting in release of catecholamines and corticosteroids, increased gluconeogenesis, insulin resistance and impaired glucose utilization. Hyperglycemia has been associated with increased morbidity and mortality and many patients will require intensive insulin therapy to keep blood glucose below a level of 200 mg/dl.

Underfeeding is commonly inadvertent, and results from underestimation of the daily calorie or protein requirements of patients and failure to take into account increased requirements due to the disease state. Other reasons are misconceptions related to enteral feeding in patients with abdominal disease or measurable gastric residue. Variable content of kitchen feeds may also contribute to inadequate delivery of nutrients. Involvement of the hospital dietician in routine care of ICU patients can avoid underfeeding.

Refeeding syndrome is seen when full nutritional requirement is suddenly established in individuals with chronic severe malnutrition. Risk factors include body mass index (BMI) <16kg/m², weight loss of >15% in 3-6 months, little or no nutrition in last 10 days, or low levels of phosphate, potassium or magnesium prior to feeding. When adequate calories are provided to these patients, there is intracellular shift and utilization with intracellular shift of phosphate, potassium, magnesium and thiamine. This causes cardiovascular abnormalities like ventricular arrhythmias, left ventricular failure, pulmonary edema and shock. Muscle damage results in myopathy, rhabdomyolysis, respiratory weakness, dyspnoea and failure to wean from ventilation. Other manifestations include confusion, Wernicke’s encephalopathy, metabolic acidosis, paresthesiae and tetany. Refeeding syndrome is prevented by starting with 5 to 10 kcal/kg/day, which is gradually increased to full requirements in 4-7 days. Cardiac rhythm should be closely monitored. Adequate provision of fluids, trace elements and vitamins, especially thiamine, is important. Intravenous supplementation of potassium, phosphate and magnesium is required. However, intravenous phosphate is not available in India and enteral replacement is done.

Complications of enteral nutrition are diarrhea, misplacement of the feeding tube, blockage and failure to achieve the target calorie goals often owing to frequent interruption of feeds for procedures or investigations like CT scans, ultrasonography and transesophageal echocardiography. Early feeding of the critically ill in the ICU is associated with a 50% reduction in mortality, but there is also a 50% increase in infection risk. Infectious complications of enteral feeding are greatly reduced when a strict feeding protocol is followed. This includes 30-45% propped up position, continuous feeding, monitoring of gastric residual volume, judicious use of prokinetic agents and post-pyloric feeding in selected cases.

The main reservations about widespread use of parenteral nutrition are the cost and the high incidence of complications with catheter-related blood stream infection being the most dreaded with an attributable mortality of 12 to 25%. Complications of parenteral nutrition are central line placement-related (pneumothorax, accidental arterial puncture and local hematoma formation), related to prolonged presence of the venous access (infection, venous thrombosis, central line blockage) and metabolic (electrolyte disturbances, acid-base disorders, liver dysfunction, hyperglycemia and trace element or essential fatty acid deficiency).

**MONITORING OF NUTRITION**

Efforts to provide greater than 55-60% of the target calorie requirement within 1st week of ice stay should be made in order to achieve clinical benefit. Tolerance of enteral feeding should be determined by looking for abdominal distension, pain, bloating, passage of stools, and monitoring gastric residual volume. Reliance on gastric residual volumes alone is not an ideal method to monitor tolerance and overzealous emphasis of the gastric residual volume has been proven to hinder the achievement of daily calorie intake goals.10 Gastric residue should be aspirated with a syringe every 6 hours; volumes of up to 500 ml are acceptable, and propping up to 45%, addition of gastric prokinetic agents like erythromycin or metoclopramide and use of continuous feeding will improve tolerance of enteral feeds.11 If high gastric residue persists in spite of these measures it is imperative to place the feeding tube (endoscopically or otherwise) in the duodenum or jejunum as intestinal motility is better preserved in critical illness than that of the stomach. Most patients receiving post-pyloric feeding will not tolerate intermittent bolus feeding. Diarrhoea should be looked for in patient receiving enteral feeds and should be evaluated to differentiate between infective and osmotic etiology.

In patients receiving parenteral nutrition, bedside blood glucose monitoring should be performed several times a day. BUN, creatinine, electrolytes and bicarbonate should be monitored daily for the first few days. Phosphate, calcium, magnesium and albumin are checked at least once a week. Clinical features of vitamin, trace element and essential fatty acid deficiency are now rarely seen since most enteral formulae
contain adequate quantities of these nutrients. However, they may still be encountered if these are not supplemented in patients on parenteral nutrition. Obtaining trace element mixtures for IV use is a particular problem in India. Onset of hepatic dysfunction may require decrease in the calories provided by the parenteral nutrition.

**NUTRITION IN SPECIAL SITUATIONS**

**Acute Renal Failure**

Unlike chronic kidney disease, patients with acute renal failure do not require protein restriction. Most patients will be oliguric and calorie dense formulae may be required to provide adequate calories without causing fluid overload. Potassium restriction may be needed. Protein requirements may be as high as 2.5 g/kg/day if the patient is receiving dialysis or continuous renal replacement therapy.

**Hepatic failure**

Nutritional and protein requirements should be in keeping with standard requirements of ICU patients. Branch chain amino acids may be useful to reduce grade of coma in few patients who do not respond to usual anti-encephalopathy measures.

**Pancreatitis and inflammatory bowel disease**

All attempts to feed patients enterally, even in severe acute pancreatitis. In severe 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. The likelihood of successful enteral feeding is greater with nasojejunal feeding and use of continuous feeding. In difficult cases switching protein to small peptide based nutrition, and using medium chain triglycerides instead of long chain triglycerides may be helpful. In case enteral nutrition cannot be established for at least 5 days, parenteral nutrition needs to be started.

**PHARMACONUTRIENTS**

Enteral glutamine is a conditionally essential amino acid which promotes gut mucosal integrity antioxidant defenses, immune function, production of heat shock proteins, and nitrogen retention and may be helpful in trauma and burns.

Immune-modulating enteral formulations containing arginine, glutamine, nucleic acid and ω-3 fatty acids are useful for patient population with major elective surgery, trauma, burns, head and neck cancer, and critically ill patients on mechanical ventilation. Arginine supplementation is known to cause improvement in nitrogen balance and protein synthesis and is also known to improve immunity parameters post stress and surgery. Arginine is best avoided in patients with severe sepsis as it may worsen hemodynamics by increasing nitric oxide production.

Use of an enteral formulation fortified with fish oil (which contains ω-3 fatty acid eicosapentaenoic acid and docosahexaenoic acid), borage oil (rich in gamma-linolenic acid), and antioxidants may reduce length of stay in the ICU and improve survival in patients with acute lung injury and ARDS by exerting an anti-inflammatory effect.

**CONCLUSION**

Nutrition is an important and often overlooked aspect of critical care. Over the last few years, several emerging concepts have changed the role of nutrition from one of providing normal daily requirement of nutrients and metabolic support to one where pharmacologic doses of nutritional supplements may actually change the course and outcome of critical illnesses. While initial trails using pharmaconutrition have shown great promise, current research does not provide evidence for the routine use of these modalities in most critically ill patients with shock, sepsis or organ failure. Randomized controlled trials are in progress and their results may change the way that we provide nutrition to ICU patients in future.

**REFERENCES**


