Between 15–40% of patients admitted to UK hospitals are malnourished at the time of their admission. Many undergo major elective or emergency surgery necessitating management in critical care units. Even if well-nourished previously, patients admitted to critical care units for trauma, burns, sepsis or other major inflammatory processes such as pancreatitis are likely to become malnourished due to significant catabolism. Total energy expenditure in these conditions is approximately 25–31 kcal kg\(^{-1}\) day\(^{-1}\) in the first few days rising to 47–59 kcal kg\(^{-1}\) day\(^{-1}\) in the second week. Complications associated with inadequate nutritional support include: (i) impaired wound healing; (ii) reduced muscle strength resulting in immobility; (iii) difficulty in weaning from ventilatory support; and (iv) increased risk of respiratory infection.

Therefore, the provision of nutritional support has become a routine ‘treatment’ in critical care units and, over the past decade, there has been particular focus on the route of delivery and the composition of the feed. The aim of this article is to review these interventions and to present a template for the basic requirements of a nutritional regimen for critically ill patients.

**Which route should we use, enteral or parenteral?**

Having decided that nutritional support is necessary, many intensivists provide nutrition by the enteral route in order to maintain gut mucosal integrity and avoid problems with sepsis secondary to bacterial translocation. Whilst this is an attractive theory, the data are somewhat conflicting and the ability to deliver sufficient nutrition to meet demands by this route can be compromised by problems with gastric emptying, tube displacement and risk of pulmonary aspiration. It may be several days before nutritional requirement is fully met and, in many cases, this is never achieved. However, the use of protocols and perseverance can lead to the successful delivery of enteral nutrition.

Post-pyloric feeding has undoubtedly revolutionised the delivery of enteral feeds. This is particularly relevant in acute severe pancreatitis where post-pyloric feeding is now a recommended technique instead of strict bowel rest. Naso-jejunal tubes can be inserted endoscopically or fed directly through the duodenum by the surgeon at the time of laparotomy. Percutaneous jejunostomy and surgically sited needle jejunostomies are being used more frequently and there is a growing body of evidence to support this practice. A variety of double, and even triple, lumen naso-gastric/naso-jejunal tubes are now available to facilitate gastric decompression thereby reducing the risk of aspiration.

Is parenteral nutrition (PN) such a bad option? There is certainly a variety of problems associated with its use. Septic complications are common. Hyperglycaemia, acidosis and dehydration, which were common in the era of hyperalimentation, should be less common today. Fatty liver due to the deposition of fat in the hepatic bed can also occur as a result of overprovision of calories. It is less clear whether this complication is related to the carbohydrate or fat component of PN.

Therefore, should we risk underfeeding seriously ill patients in order to avoid using PN? The only absolute indication is ‘gut failure’. However, in a large percentage of critical care patients, some degree of gut malfunction occurs as a result of surgical interventions, multiple organ dysfunction and drugs, including sedatives and antimicrobials. Despite complications, PN does ensure 100% bioavailability. Recently, the use of a combined enteral and parenteral
approach has been advocated as a suitable way of ensuring that full nutritional support is delivered safely. Further studies are required to demonstrate clear benefits of this technique.

**Delivering parenteral nutrition**

The choice of route for delivery of PN has increased over the past few years. The majority of critically ill patients will have multilumen central venous catheters. One of the lumens is used for enteral feeding and others for measurement of central venous pressure or administration of vasoactive drugs. Although convenient, there is a risk of introducing infection. Therefore, it is preferable to utilise dedicated vascular access for PN.

Small bore (20 G) polyurethane catheters can be inserted into forearm veins for administration of PN. The nature of the catheter material reduces the risk of thrombophlebitis. Also, peripheral administration of PN limits the formulation of the solution. In general, a lower osmolar load is given to avoid irritation of the vein. Other strategies, such as the addition of heparin and/or hydrocortisone, have been used to ameliorate the problem. A more recent development has been the peripherally inserted central catheter (PICC) introduced via an antecubital fossa vein. PICCs are also made of materials which have a low potential for thrombogenesis and they can be used for several weeks without imposing limits on solution formulation.

**How much should be given?**

The simple answer to this question is ‘enough’. However, this can be difficult to ascertain. Indirect calorimetry can be used, but this has limitations. Also, it is not clear whether all the calculated calorie requirements should be administered; probably not if hyperglycaemia, hypercarbia, acidosis and fatty liver are to be avoided. Twenty-four hour urine collections for measurement of urea as a surrogate for nitrogen requirements is another flawed technique in the unstable critically ill patient. There is widespread fluctuation from day-to-day in measured concentrations and deriving nitrogen or protein requirements by this method is difficult.

There are also other constraints in terms of the volume of feed one can safely deliver, e.g. renal failure and ARDS. Most critical care units have standardised formulations and Table 1 summarises a typical regimen. However, these regimens are frequently modified for an individual patient with specific problems (e.g. liver failure, renal failure, chronic obstructive airway disease, ARDS).

### Table 1 A typical regimen for providing enteral or parenteral nutritional support in critically ill patients

<table>
<thead>
<tr>
<th>Component</th>
<th>Requirement</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid/water requirements</td>
<td>25–35 ml kg⁻¹ 24 h⁻¹</td>
<td>May be restricted in renal failure or ARDS</td>
</tr>
<tr>
<td>Protein/nitrogen requirements</td>
<td>0.15–0.20 g nitrogen kg⁻¹ 24 h⁻¹</td>
<td>(1 g nitrogen = 6.25 g protein)</td>
</tr>
<tr>
<td>Energy requirements</td>
<td>25–40 kcal kg⁻¹ 24 h⁻¹</td>
<td>(rarely &gt; 35 kcal kg⁻¹ 24 h⁻¹)</td>
</tr>
<tr>
<td>Carbohydrate (4 kcal g⁻¹)</td>
<td>Usually mixed source with both carbohydrate and fat</td>
<td></td>
</tr>
<tr>
<td>Fat (9 kcal g⁻¹)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minerals</td>
<td>Calcium 0.11 mmol kg⁻¹ (± 2.25 mmol)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Magnesium 1 mmol kg⁻¹ (± 2 mmol)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phosphate 0.5 mmol kg⁻¹ (± 10 mmol)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zinc 0.3 µmol kg⁻¹</td>
<td></td>
</tr>
<tr>
<td>Vitamins/trace elements</td>
<td>Fat and water soluble vitamins plus additrac</td>
<td></td>
</tr>
</tbody>
</table>
benefits. However, in trauma patients, a reduction in sepsis and other infective complications has been demonstrated.

Arginine is another amino acid capable of modifying immune response. It has particular effects in promoting T cell proliferation and macrophage and natural killer cell function and its beneficial effects on the immune system are thought to be related to its role as a precursor for both polyamines and nitric oxide (NO). Polyamines are involved with DNA synthesis and NO regulates vascular tone, coagulation and the immune system.

Most of the studies involving the use of arginine have looked at it in combination with omega-3 fatty acids and ribonucleotides. The former have both anti-inflammatory (down regulation of prostaglandins) and immuno-stimulatory properties whilst the latter promote protein synthesis and probably have actions on T-cell function. In postoperative cancer patients, when compared with a standard enteral feed, this combination has been shown to improve nitrogen balance and lymphocyte activity along with significant reductions in late complications, infection rates and length of stay. In peri-operative feeding of patients with colorectal cancer, arginine, in combination with omega-3 fatty acids and ribonucleotides, increases microperfusion, oxygen metabolism and NO concentrations in the GI tract. In different studies involving heterogeneous groups of critical care patients, its use has been shown to significantly reduce nosocomial infection rate, bacteraemia, duration of ventilation, length of stay and overall mortality.

Taurine is an abundant amino acid with roles in membrane stabilisation and calcium flux regulation. It has anti-oxidant properties and also primes leukocytes whilst modulating release of pro-inflammatory cytokines. Like glutamine, it may be conditionally essential and low GI tract concentrations have been shown in multiple trauma patients. No clinical trials have yet been published, but it is expected that the taurine-induced modification of the cytokine profile will be beneficial.

Other immunonutrients include phospholipids, which have been shown to reduce bacterial translocation following liver resection, and soluble fibre which has GI trophic and mucosal protective effects. Finally, probiotic bacteria, e.g. Lactobacillus plantarum, prevent overgrowth by pathogenic organisms. It is expected that specialised feeds containing such organisms will soon be available.

Conclusions

Nutritional support of the critically ill patient is undoubtedly an important element of the overall package of care. Whilst attention has focussed on enteral feeding as the preferred route, often at the expense of quantity, there is a growing recognition of the need to provide sufficient support by whatever route. A variety of techniques for the delivery of both parenteral and enteral nutrition are now available in an attempt to minimise complications and maximise patient benefit. The use of post-pyloric enteral feeding has received particular attention. Modification of feed components is a constantly evolving field and, whilst we have already seen published evidence of benefit for glutamine and arginine, there is wide range of other substances under investigation which might yet prove even more beneficial to the critically ill patient.

Key references


Spain DA, McClave SA, Sexton LK et al. Infusion protocol improves delivery of enteral tube feeding in the critical care unit. JPEN 1999; 23: 288–92


See multiple-choice questions 8–12.