Nutrition in critical care

Objective

• To provide recommendations for the assessment and management of the nutritional needs of critically ill patients.

Introduction

The Intensive Care Unit (ICU) is a specialised area of a hospital which has the facilities, equipment and staff expertise required to manage patients with life-threatening conditions. Patients in an acute hospital are classified according to their severity of illness rather than their hospital location (Table 16.1). Generally, the patients on the ICU will be level 2 (high dependency) or level 3 (intensive) (Faculty of Intensive Care Medicine and Intensive Care Society, 2015).

Although the ICU specialist dietitian is likely to cover all areas of critical care (including level 2), use of ‘ICU,’ ‘critical care’ and ‘critically ill’ throughout this section refers to level 3 patients.

Table 16.1. Classification of patients in the acute hospital setting (Department of Health, 2000).

<table>
<thead>
<tr>
<th>Classification</th>
<th>Level of support required</th>
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<tbody>
<tr>
<td>Level 0</td>
<td>Patients whose needs can be met through normal ward care in an acute hospital.</td>
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<tr>
<td>Level 1</td>
<td>Patients at risk of their condition deteriorating, or those recently relocated from higher levels of care, whose needs can be met on an acute ward with additional advice and support from the critical care team.</td>
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<tr>
<td>Level 2</td>
<td>Patients requiring more detailed observation or intervention, including support for a single failed organ system or postoperative care and those stepping down from higher levels of care.</td>
</tr>
<tr>
<td>Level 3</td>
<td>Patients requiring advanced respiratory support alone or basic respiratory support together with support of at least two organ systems.</td>
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Appropriate nutrition provision in the ICU is associated with improved patient outcomes, reduced length of hospital stay, decreased duration of dependence on mechanical

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ventilation and reduced infections (Villet et al. 2005). The best available evidence has been used to formulate these recommendations, however it is imperative that the ICU dietitian remains up to date with the current literature and changes practice accordingly. **Clinical judgement** at the bedside is warranted at all times.

**Nutritional screening and assessment**

Traditional screening tools for determining the risk of malnutrition, such as the ‘Malnutrition Universal Screening Tool’ (see Section 1), are not accurate in critically ill patients (Anthony, 2008). However, current international guidelines (McClave et al. 2016) recommend nutrition risk scoring e.g. Nutrition Risk Screening 2002 (NRS) (Kondrup et al. 2003), Nutrition Risk in the Critically Ill (NUTRIC) (Heyland et al. 2015) for all patients (based on expert consensus). Nutrition risk may distinguish between those patients who may benefit the most from nutrition support and those who may not. However, limitations exist (Table 16.2).

**Table 16.2. Nutritional screening tools and limitations.**

**NRS-2002** (Kondrup et al. 2003):
- Detects the presence of undernutrition and risk of developing undernutrition.
- May not be specific enough for critically ill patients due to the classification of all patients with an Acute Physiology and Chronic Health Evaluation (APACHE) score. APACHE II >10 being classified as high risk.

**NUTRIC score** (Heyland et al. 2015):
- Specifically developed and validated for the critically ill patient.
- Its purpose is to help identify which critically ill patients are most likely to benefit from optimal amounts of macronutrients when considering mortality as an outcome (Rahman et al. 2016).
- Has been proposed as a tool to guide decisions regarding those who require more aggressive nutritional support (e.g. early parenteral nutrition), yet prospective data is currently lacking (Mcclave et al. 2016).
- May not be practical to undertake at the bedside due to the complexity of the severity of illness scoring required.
Regardless of whether a nutrition risk score is calculated, undertaking a nutritional assessment for all patients expected to remain mechanically ventilated for more than 48 hours is desirable.

Although it is important to consider anthropometric measures (Table 16.3), such as body weight, they should be interpreted with caution due to the inability to accurately account for shifts in fluids status. Additional factors which are included as part of the NUTRIC score, such as projected length of stay, severity of illness, comorbidities and length of stay in hospital prior to ICU admission should also be considered.

Table 16.3. Barriers to obtaining traditional anthropometric measures.

| Patients may be unable to provide a history and have no previous medical documentation of weight, height or nutritional history. |
| Weighing scales and equipment may not be available in the ICU; bed weighing scales additionally may not be calibrated. |
| Weight may fluctuate dramatically due to fluid shifts. The weight of critically ill patients can increase by 10-20% in 24hrs making readings potentially inaccurate (Lowell et al. 1990). |
| Critically ill patients are often immobile; they may not be weighed due to haemodynamic instability or unstable injuries in the context of trauma. |
| Anthropometric measurements (e.g. ulna, mid-upper arm circumference) are not validated tools in the ICU. Measurements should be considered as a guide only and used in conjunction with clinical judgement. |
| Equipment such as traction, casts and braces provide logistic difficulties and need to be accounted for in resultant measurements. |
| Adjusting body weight in amputees can add additional scope for errors. |
Initiation of nutritional support

Enteral nutrition (EN) supports the functional and structural integrity of the gut, modulates the systemic immune response and attenuates disease severity (McClave et al. 2016). In the critically ill patient who is unable to maintain their own nutritional intake, it is recommended that EN be initiated within 24 to 48 hours (Kreymann et al. 2006; Dhaliwal et al. 2013; Canadian Critical Care Society and Canadian Critical Care Trials Group, 2015; McClave et al. 2016; Reintam et al. 2017).

Feeding protocols

A feeding protocol should be standard practice in the ICU to facilitate early enteral feeding (Table 16.4). Combined with a dedicated ICU dietitian, and a training programme to increase protocol adherence, the use of a feeding protocol has been shown to increase the overall percentage of goal energy provided (Kreymann et al. 2006; Dhaliwal et al. 2013; Faculty of Intensive Care Medicine and Intensive Care Society, 2015; Canadian Critical Care Society and Canadian Critical Care Trials Group, 2015; McClave et al. 2016).

Table 16.4. Features of ICU feeding protocols.

- Specify a starter feed.
- Define target feeding rate.
- Provide details of feed advancement strategies which may include a volume-based feeding approach.
- Give specific instructions on handling gastric residual volumes (GRVs).
- Detail conditions under which enteral nutrition should be adjusted, stopped or when an alternative route of delivery (such as post-pyloric feeding) should be considered.

Limitations of feeding protocols

- Whilst feeding protocols are extremely useful in the early stages of feeding, they do not account for differences between patients (such as BMI or nutritional status), feed interruptions, or changes in clinical condition.

- Although they make recommendations for alternative feeding strategies (e.g. post-pyloric), this is not enough to ensure that these are always used when appropriate.

- Use of feeding protocols alone is therefore not sufficient to prevent nutritional deficits, and therefore
individualised nutrition support from a specialist dietitian is required in those patients who remain on ICU for longer than 48 hours (Singer et al. 2011).

**Volume-based feeding**

- Volume-based feeding is a relatively new practice which is being increasingly implemented by dietitians in the critical care setting.

- Volume-based feeding protocols focus on delivering daily volumes of feed rather than a target hourly rate.

- Examples include the PEP Up protocol (Heyland et al. 2013; McCall et al. 2014) or the FEED ME protocol (Taylor et al. 2014), which has been shown to increase nutrition provision in the critical care patient.

- These types of protocols allow nursing staff to calculate the remaining daily feed volume to be delivered and to adjust the rate of feeding to accommodate e.g. time lost to investigations, procedures, airway management (Table 16.5).

**Table 16.5. Frequent feeding barriers in the critical care setting.**

- Fasting for procedures (e.g. surgical interventions, tracheostomy).
- Fasting for diagnostic tests.
- Feeding tube placement (e.g. tube displacement, delays in tube insertion/confirmation of position).
- High gastric residual volumes with cessation of feeding.
- Gastrointestinal (GI) intolerance (e.g. vomiting, nausea, ileus).
- Non-feed energy sources (e.g. propofol, citrate, glucose).

**Route of feeding**

It is practical and safe to use enteral nutrition (EN) in most critically ill patients.

**Enteral Nutrition vs. Parenteral Nutrition**

- The advantages of EN over parenteral nutrition (PN) include: reduced cost, maintenance of gut integrity, modulation of the immune response and a reduced risk of septic complications (Kreymann et al. 2006; Dhaliwal
et al. 2013; Canadian Critical Care Society and Canadian Critical Care Trials Group, 2015; McClave et al. 2016).

- However, the CALORIES trial found no infectious outcome differences between the administration of early EN or PN, when PN dose is equivalent to EN dose, suggesting improvements in ICU PN management practices in England (Harvey et al. 2014).

- A recent systematic review suggests that the advantages of EN compared to PN may be attributed to differences in caloric intake rather than the route. Therefore, if some degree of hypocaloric feeding is used, PN may be as safe as EN in the critically ill patient (Elke et al. 2016).

Initiation of PN

- In critically ill patients where EN is contraindicated or does not meet nutritional targets, full or supplemental PN should be considered to prevent the risks associated with underfeeding.

- The recommended timing of the initiation of PN is unclear but international guidelines suggest that exclusive PN should be withheld for the first 7 days following ICU admission in patients at low nutrition risk and commenced as soon as possible in those at high nutrition risk (Casaer et al. 2011; Harvey et al. 2014; Elke et al. 2016; McClave et al. 2016).

Supplemental PN

- A combination of PN with EN should be considered when EN fails to meet nutritional targets (Heidegger et al. 2013; McClave et al. 2016).

- Other strategies, such as prokinetics and post-pyloric feeding should be attempted first.

- Early supplemental PN is not advised in critically ill patients as it is costly and provides minimal benefits (Heyland, 2012).

Summary

- In the absence of more conclusive guidance, the need for PN should be considered on a case-by-case basis.

- The ICU dietitian is integral to this decision-making process and can reduce the inappropriate use of PN (Faculty of Intensive Care Medicine and Intensive Care Society, 2015).
• Close monitoring of critically ill patients receiving PN is required to prevent overfeeding and associated hyperglycaemia (Casaer et al. 2011; Casaer et al. 2013).

Estimation of nutritional targets in critically ill patients

Energy

• Provision of energy is a balance between too little and too much – both presenting with their own risks (Faisy et al. 2009; Casaer et al. 2011; Schetz et al. 2013; Faculty of Intensive Care Medicine and Intensive Care Society, 2015). Current data suggests that optimal energy provision may be 70% of measured energy expenditure (MEE) (Zusman et al. 2016) or 80% of estimated targets (Heyland et al. 2011) over the first week of ICU stay when considering mortality as an outcome.

• Indirect calorimetry (IC) is the gold standard for measuring resting energy expenditure (REE). See Section 3. However, due to several factors, the use of IC is not currently widespread in clinical practice (McClave et al. 2016).

• Weight-based predictive equations remain the primary tool for estimating energy targets (Table 16.6 and Table 16.7).

• The clinical condition of the patient (i.e. ventilated or non-ventilated) and the different phases of critical illness (catabolic vs anabolic/recovery) should be considered when choosing an appropriate predictive equation (Table 16.6 and Table 16.7).
PULL OUT SECTION
TABLE 16.6
PULL OUT SECTION
TABLE 16.7
Underfeeding

- Cumulative energy deficits are associated with poorer patient outcomes including an increased length of hospital stay, prolonged time needing mechanical ventilation and increased risk of infection (Faisy et al. 2009; Schetz et al. 2013; Faculty of Intensive Care Medicine and Intensive Care Society, 2015).

- However, these outcome measures have not been confirmed in randomised controlled trials (RCTs) when comparing either trophic feeding or permissive underfeeding to full planned feeding (Rice et al. 2012; Arabi et al. 2015).

Overfeeding

- Overfeeding can lead to the exacerbation of hypercapnia, hyperglycaemia, hypertriglyceridemia and fatty liver, uraemia and metabolic acidosis. See Section 9. The risk of adverse complications is likely to be highest during the initial phase of critical illness (Casaer et al. 2011).

- Non-feed energy sources such as the anaesthetic drug Propofol, glucose and regional citrate anticoagulation used in haemodialfiltration (see Section 14) should be considered when their contribution amounts to a significant volume of energy for an extended duration of time (Table 16.5).

Obesity

- There is a distinct lack of evidence base for the estimation of energy targets in the critically ill obese patient.

- It is likely that body composition (muscle mass vs fat mass) will have an impact on nutritional targets. However, in the absence of a bedside method to do this, clinical judgement is warranted.

- Hypocaloric high protein feeding (HCHP) is recommended (McClave et al. 2016). Recommendations are based on expert consensus considering two RCT’s (Burge et al. 1994; Choban et al. 1997), which only included a small number of critically ill obese subjects (Table 16.6).

- Protein supplementation may need to be used to achieve HCHP feeding.

- Identify nutrition risk as with a non-obese patient (see Section 2) as a hypocaloric strategy is not applicable for all obese patients (Alberda et al. 2009).
The Penn State University (PSU) equation (Table 16.6 and Table 16.7) has been validated in the obese patient.

Be aware of the limitations of all the predictive equations currently available (for both obese and non-obese patients)

Regular monitoring and at least weekly re-estimation of requirements by a critical care dietitian will minimise risk of over/under feeding

Protein

- Protein catabolism is increased in the critically ill patient and nutritional support cannot completely eliminate the subsequent skeletal muscle wasting (Shaw et al. 1987; Japur et al. 2010).

- The evidence base for protein targets is poor due to a lack of high quality randomised controlled trials (Ishibashi et al. 1998; Ferrie et al. 2016) and as a result makes it difficult to give clinical recommendations. Observational studies however suggest that higher protein intake is associated with improved outcomes such as hospital mortality (Hoffer and Bistrian, 2012; Weijs et al. 2012). One observational study suggested that achieving at least 80% prescribed protein intake may be important to survival (Nicolo et al. 2016).

- Critical care guidelines suggest a protein intake between 1.2-2g/kg/day (Kreymann et al. 2006; Singer et al. 2009; Dhaliwal et al. 2013; McClave et al. 2016). Table 16.8 highlights suggested recommendations for protein targets in critically ill patients based on expert opinion in relation to clinical condition.

- Protein supplementation/high protein formulas may need to be considered if there is a need to reduce calories considerably secondary to non-feed energy sources.
Table 16.8. Recommendations for protein targets in critically ill patients.

<table>
<thead>
<tr>
<th>Patient group</th>
<th>Protein Target (g/kg/ABW)*</th>
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<tbody>
<tr>
<td>General ICU (Faisy et al. 2009)</td>
<td>1.2-1.5</td>
</tr>
<tr>
<td>Trauma (Faisy et al. 2009)</td>
<td>1.3-1.5</td>
</tr>
<tr>
<td>Burns (Rousseau et al. 2013)</td>
<td>1.5-2.0</td>
</tr>
<tr>
<td>Continuous renal replacement therapy (KDIGO, 2012; McClave et al. 2016, Patel et al. 2017) (see Section 14)</td>
<td>1.5-2.5</td>
</tr>
<tr>
<td>Obese** (Choban et al. 2013)</td>
<td>2.0-2.5 (g/kg/IBW/day)***</td>
</tr>
</tbody>
</table>

*ABW = actual body weight; ** to be used in obese patients irrespective of clinical condition; *** IBW = Ideal body weight (see Section 2)

Fluid
If volume restricted EN/PN is required due to tight fluid targets during critical illness then discussions with the medical team are imperative to ensure energy, protein and micronutrient targets are still met.

Overall responsibility lies with the medical staff. Baseline requirements can be estimated using the information in Section 3, Table 3.11.

Micronutrients
Evidence to support a clinical benefit from the routine supplementation of vitamins and minerals in the critically ill patient is conflicting (Koekoek and Van Zanten, 2016). Consequently, there is insufficient data to make recommendations for clinical practice.

Some patient groups may have high requirements for specific micronutrients, for example, burns patients, those on continuous renal replacement therapy (Berger et al. 2004) or those with a deficiency (e.g. patients with high alcohol consumption or at risk of refeeding syndrome) (NICE, 2006). In these patients, supplementation should be provided in accordance with local and national guidelines.
Immune modulating nutritional support

- Immune modulating enteral feeds contain added ‘functional’ substrates which may include; arginine, glutamine, n-3 polyunsaturated fatty acids, nucleotides and antioxidants (e.g. selenium and vitamin C).

- The use of these formulae remains controversial as the published studies differ in the combination and quantity of substrates used, the timing of their use and the type of critically ill patient studied (Marik and Zaloga, 2008; Heyland et al. 2013; Van Zanten et al. 2014). Consequently, no overall synthesis of the results is possible (Kreyman et al. 2006; Dhaliwal et al. 2013; Canadian Critical Care Society and Canadian Critical Care Trials Group, 2015; McClave et al. 2016) and therefore immunonutrition should not be routinely used in the critically ill patient.

- Similar issues with study heterogeneity arise with studies investigating the use of parenteral glutamine and selenium supplementation (Andrews et al. 2011; Bollhalder et al. 2013). Recent international guidelines recommend that parenteral glutamine supplementation should not be used routinely in the critical care setting (McClave et al. 2016).

Barriers to nutritional delivery

- Delivery of energy and protein is frequently reported to be below prescribed levels (Alberda et al. 2009). Table 16.5 highlights some of the causes of feed interruptions that commonly occur in the ICU setting.

- The implementation of specific strategies (e.g. fasting guidelines, enteral feeding protocols, volume-based feeding strategies) can help to reduce the volume of missed feed and minimising avoidable causes of feed cessation should be encouraged.

Gastrointestinal intolerance

Gastrointestinal (GI) intolerance is a frequent occurrence in the critically ill patient (Nguyenn et al. 2007) and can manifest itself in several ways, including delayed gastric emptying, vomiting, abdominal distension, diarrhoea and constipation. The causes of GI intolerance are multifactorial (Mentec et al. 2001; Deane et al. 2007) and evidence suggests that patients who develop GI dysfunction in the ICU have worse outcomes (Mutlu and Factor, 2001; Gungabissoon et al. 2015).
Gastric residual volumes

- GRV measurements (usually 4-6 hourly) have been used as a surrogate measure of gastric emptying which is assumed to reflect tolerance and absorption of feed.

- Two studies (McClave et al. 2005; Montejo et al. 2010) found no increase in the incidence of aspiration or ICU acquired pneumonia when GRV cut off was increased to 400ml and 500ml respectively in comparison to a cut off value of 200ml.

- One study also found that the mean volume of enteral feed delivery was significantly greater in the increased GRV group (McClave et al. 2005). Because of these findings most centres now tolerate higher GRV, with some experts questioning the need for measuring GRV at all (Reignier et al. 2013).

- Patient population (e.g. medical vs surgical) should be considered when deciding the best GRV measurement protocol for individual ICUs.

Prokinetics

- Prokinetics are commonly used to enhance the delivery of EN in critically ill patients who have delayed gastric emptying.

- Both metoclopramide and erythromycin are used as prokinetic drugs, with combination therapy demonstrating an increased rate of successful feeding compared with monotherapy in critically ill patients (Nguyen et al. 2007).

- Tachyphylaxis and side-effects have been reported for both agents and consequently metoclopramide is commonly utilised as first line treatment (10mg IV 8 hourly). If large GRVs persists, erythromycin (250mg IV 6 hourly) is added (always refer to local policies for dose recommendations).

- Exact practice will vary across units, however alternate feeding routes should be considered if enteral feeding remains unsuccessful.

Post-pyloric feeding

- Post-pyloric feeding may be considered in patients with delayed gastric emptying as an alternative method for successfully delivering enteral nutrition when gastric feeding has failed.
• Jejunal feeding can be administered via post-pyloric feeding tubes or via a surgically inserted jejunostomy. Post-pyloric feeding tubes can be inserted via endoscopy or radiology, or at the bedside with the use of specialist equipment.

Enteral feed choice in ICU
• For most critically ill patients, a polymeric formula is suitable and recommended.

• High protein feeds or modular protein supplements are often used to meet the protein needs of critically ill patients whilst avoiding excessive amounts of energy.

Low sodium feeds
• Hypernatraemia is common in the critically ill patient and is often due to inadequate fluid administration, excessive sodium administration or high fluid losses (Lindner and Funk, 2013).

• Enteral nutrition is unlikely to be the cause and therefore the use of a low sodium feed (which can also be low in protein) is not routinely advised.

• It is important that the cause of hypernatraemia is identified and appropriately managed by the multidisciplinary team. This may involve the use of additional enteral water or a review of the prescribed medications to identify and potentially alter those high in sodium.

Specialist renal feeds
• A low electrolyte, low volume or specialist renal feed is not indicated for patients with acute kidney injury who are receiving continuous renal replacement therapy.

• However, these feeds may be appropriate for patients with deteriorating renal function who are not receiving renal replacement therapy or those on intermittent haemodialysis who require fluid restriction.

• As some of these feeds are also low in protein, an additional source of protein may be required.
Key points
• Estimating energy and protein requirements in critically ill patients is challenging.
• Feeding protocols should be standard practice in the ICU to facilitate early enteral feeding.
• Enteral feeding is the route of choice and the need for parenteral nutrition should be considered on a case by case basis.
• Provision of nutrition support in critically ill patients is complex and requires the skills of a specialist dietitian.

References


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