Nutritional Support in Intensive Care Unit (ICU) Patients

Topic 18

Module 18.2
More than Choosing the Route: Enteral and Parenteral Nutrition

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Learning objectives

- Learn the possible routes of feeding;
- Situations where early enteral nutrition is shown to be beneficial and when parenteral nutrition can be suggested;
- Understand the obstacles to each route;
- Learn how to overcome the obstacles;
- Apply the proposed protocols to reach the target.

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Key Messages

- Increased nutritional requirements during critical illness must be matched by appropriate infusion of calories and nitrogen, especially when severe malnutrition is present, in the case of insufficient oral intake or expected delay before recovery of eating;
• Early enteral nutrition can be systematically considered in patients unlikely to recover their ability to eat within 48 hours after injury; if not achievable, parenteral nutrition should be considered soon or later;
• Inappropriately high amounts of energy-yielding substrates can lead to detrimental effects, especially after a long period of fasting;
• The use of local algorithms and protocols is recommended to optimise nutrition support.

1. Implementation of Nutrition Support

In general terms, the increased energy and protein requirements during critical illness must be matched by appropriate infusion of calories and nitrogen. Therefore, the implementation of nutritional support in a critically ill patient is obviously indicated when at least one of the three following criteria is present:

- Pre-existing severe malnutrition
- Oral intake matches < 50% of the energy and nitrogen needs
- Expected delay before recovery of eating ≥ 3 days

1.1. Route of Feeding

Most of the literature regarding the provision of nutrition therapy finds strong evidence that enteral nutrition significantly reduces mortality in the critically ill patient (1). There is a strong recommendation for enteral nutrition compared to any form of standard care, including IV dextrose or waiting for return to oral intake (2, 3). Providing enteral nutrition early (within 48 hours) is also associated with a reduction of mortality, without significant side effects, as well as a reduction in overall hospital costs (4, 5). As a general rule, administration of nutritional support is required in critically ill patients to limit the negative energy and protein balance observed in these patients. Enteral nutrition is always preferable to parenteral nutrition. The absence of gut feeding, or gut starvation may represent an important trigger for systemic infections due, typically, to gastro-intestinal micro-organisms. Numerous disturbances found at different levels of the gastrointestinal tract have been described and are summarised in Table 1.

**Table 1**

Consequences of starvation on the gastrointestinal tract

<table>
<thead>
<tr>
<th>Gut barrier (epithelial cell junction)</th>
<th>Increased permeability to macromolecules and micro-organisms (bacteria, fungi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enterocytes</td>
<td>Increased adherence of bacteria</td>
</tr>
<tr>
<td>Intestinal flora</td>
<td>Overgrowth of pathogens</td>
</tr>
<tr>
<td>Sub-mucosal immune system</td>
<td>Atrophy of Peyer's patches. Decreased production of immunoglobulin A</td>
</tr>
</tbody>
</table>

Indeed, the absence of nutrients in the gastrointestinal tract has 3 consequences:
1) lack of fuel source for enterocytes
2) lack of mechanical stimulation
3) abnormal hormonal pattern

Therefore, the absence of nutrients has been proposed as a trigger for the translocation of endotoxins, bacteria and fungi from the gastrointestinal tract (GIT) lumen into the blood stream despite the liver “filter”, inducing a metabolic response, and a generalised
whole-body response to a second “hit” that may induce a systemic inflammatory response to stress and multi-organ failure.

Early enteral feeding and even a small amount of nutrients in the gastrointestinal tract may prevent this translocation process.

In some cases, enteral feeding is not able to reach the nutritional targets proposed by clinicians because of GIT intolerance, or because the GIT is not available, as well as because of technical issues. In these cases, nutrition is indicated mainly for patients with an expected long stay in the ICU (6). Parenteral nutrition can be used alone or as a supplementary measure (7). It has been demonstrated to be safe and may even have some clinical advantages in terms of mortality over enteral feeding (8). The timing of supplemental parenteral nutrition is however a subject of debate.

1.2. Timing of Implementation

Strong evidence and consensus exist supporting early (<48 hours) enteral nutrition (9). This issue requires the assessment of possible benefits from early (<48h) enteral nutrition. If the patient is not likely to benefit from early enteral nutrition, delayed artificial nutrition (preferentially enteral) or parenteral should be instituted if the patient is not expected to recover the ability to cover his caloric and protein requirement for 5-7 days (see discussion in the “choice of route” unit of this module). Early (10, 11) or late (12) implementation of supplemental parenteral nutrition in critically ill patients has been studied with conflicting results. Therefore, the parenteral route should be used only when the gastrointestinal function does not allow the administration of enteral nutrition, or when the tolerated amount of enteral feed is felt largely insufficient over a prolonged period. The optimal timing to start supplemental parenteral nutrition remains uncertain.

2. Enteral Nutrition: Practical Aspects

Enteral nutrition is often feasible, as the gastrointestinal tract function is usually normal, but some precautions must be taken before initiating enteral feeding (13). Lists of potential concerns and queries have to be considered before the initiation of enteral feeding in order to avoid complications. The systematic use of a checklist and of standard settings, as shown in Table 2, can be useful in starting and optimising enteral feeding.

Table 2
Checklist before starting enteral nutrition

<table>
<thead>
<tr>
<th>Significant gastrointestinal dysfunction?</th>
<th>Is the gastric residual volume &gt;500 ml?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspicion of ileus?</td>
<td>Infuse enteral feeding (20 ml/h) and check gastric residual volume 4–6 h later. Perform X ray.</td>
</tr>
<tr>
<td>Initial settings?</td>
<td>Pump-driven, continuous</td>
</tr>
<tr>
<td>Position of the feeding tube?</td>
<td>Naso- or oro-gastric. In the middle of the stomach.</td>
</tr>
<tr>
<td>Catheter type?</td>
<td>PVC</td>
</tr>
<tr>
<td>Patient position?</td>
<td>Head of bed elevation at &gt;30°</td>
</tr>
<tr>
<td>Which formula?</td>
<td>Polymeric, isoenergetic in most cases</td>
</tr>
</tbody>
</table>

2.1. Contraindications

Absolute contraindications for enteral access include:
- Complete bowel obstruction
- Vomiting, aspiration and increased gastric residues (above 500 mL)
- Haemodynamic instability with increasing doses of catecholamines
- Active upper GIT bleeding
- Fear of inducing intestinal complications such as bowel ischaemia
- No GI access
- Unsafe surgical anastomosis
- Abdominal compartment syndrome

Enteral feeding should be delayed in case of abdominal distension, abdominal compartment syndrome, bowel ischaemia, (fear of this is an absolute contraindication in the list above) active ulcer bleeding with high risk of rebleeding, and haemodynamic instability. Special attention should be given in increasing or persisting lactate levels (risk of bowel ischaemia).

There is no contraindication in the case of uncomplicated hypoxaemia, hypercapnia, acidosis, hypothermia, after small surgical procedures, the use of muscle relaxants, or in patients suffering from acute pancreatitis, after abdominal trauma, even with an open abdomen or after aortic aneurysmal surgery (13).

### 2.2. Enteral Access

Gastric access has many advantages:
- easy access
- early access
- access performed by nurses

Therefore this access should always be proposed in any case where the GIT is functioning and available.

The disadvantages are not negligible and include the risk of inhalation of gastric content, because of the supine position, gastro-oesophageal reflux and impaired gastrointestinal peristalsis. Aspiration of gastric content into the airways is a serious complication which can be life-threatening if massive, but this occurs very rarely; more often, aspiration is not obvious, is "silent" and has been proposed as a possible cause of ventilation associated pneumonia. Another possible disadvantage is nasopharyngeal trauma, which may induce profuse bleeding; this should be prevented by gentle introduction through the nose of a small bore nasogastric tube. Accidental tube displacement should be continuously suspected since initial correct fixation may be lost and the new positioning after refixation may not be reconfirmed by X-ray, or by other techniques such as pH measurement.

#### 2.2.1. Gastric Access

Gastric feeding techniques include:
- nasogastric tubes available for short-term feeding (less than 3-6 weeks), and achievable using a manual bedside placement that can be confirmed radiologically (not mandatory).
- gastrostomy available for long term feeding through the GIT tract, and achievable using endoscopic, radiologic or surgical placement.

#### 2.2.1.1. Naso-gastric Tubing and Placement

Tubes used could be made of polyvinyl (more rigid), silicone (more flexible) or polyurethane (less traumatic). Their diameter varies from 6 to 14 French. Their length can vary from 95, 105 up to 120 cm, according to the anatomy and size of the patient, and the tip could be weighted, although a confirmation of the advantage of this technique is still awaited.

The right placement of the tube must always be checked before starting enteral feeding, by pH measurement or other techniques.
Coughing, vomiting or nasotracheal suctioning, as well as removal of endotracheal tubes can induce dislodgement of the nasogastric or nasoduodenal tube. Therefore, the position of the tube should be checked regularly by nurses during their shift. In case of undetermined position, and inconclusive pH measurement, X ray should be ordered. Other tests that are no longer recommended include auscultation of insufflated air through the tube which has been shown to be unreliable. However pH analysis of aspirated juice is reliable if the sample has a pH of less than 4.5. It will be remembered that normal gastric juice pH is closer to 2-3, and duodenal pH is closer to 6-7, although biliary reflux and stress ulcer prophylaxis may represent confounding factors.

2.2.1.2. Gastrostomy

Percutaneous Endoscopic Gastrostomy (PEG) has many advantages over surgical gastrostomy (14): there is no need for surgery, it can be performed at the bedside in ICU, minimal sedation is required, and it is a short procedure with low costs. PEG should be suggested if enteral feeding is planned for more than 4-8 weeks. The aspiration risk is not decreased by PEG, but if the patient is agitated, pulling out the tube many times and/or is in a vegetative state, PEG should be recommended. The procedure is simple and the complication rate is lower than for surgical gastrostomy. It is even cost-effective. Immediate feeding has been tested in comparison with feeding the next day and in none of the parameters has any difference been found. Some patients nonetheless require a surgical or radiological procedure because of their oesophageal or abdominal condition and an expected prolonged stay in the hospital or rehabilitation centre.

The surgical techniques recommended in the event that the patient is undergoing laparotomy should be according to the surgeon’s experience, the abdominal status and the related risks of the procedure. Complications of operative gastrostomy tube placement include bleeding, but only rarely (less than 1%). Improper lodgement of the tube, or dislodgement in the anterior part of the stomach can also be found. Tube site leakage is more frequent. Wound infection occurs in 2-8% of cases.

2.2.2. Postpyloric Feeding

Postpyloric feeding is a valid option for enteral feeding of long-term patients, with gastro-duodenal dysfunction which prevents the infusion of an adequate amount of nutrients (15, 16). The advantages of postpyloric feeding (ease of administration of drugs and nutrients) must be balanced with the disadvantages of this technique (high cost, hazard of gut perforation in case of accidental dislodgement), as compared to gastric feeding and prokinetics. Many experienced teams will prefer postpyloric feeding tubes, whereas others will prefer the association of gastric feeding and pro-motility agents. No study has yet demonstrated a relevant advantage for either of these two options. Recently, techniques have been developed to improve the rate of success of introducing a nasoenteral tube. If the purpose is to introduce the tube into the duodenum, a “10-10-10” technique has been proposed. This technique proposes the administration of metoclopramide (10 mg), to wait 10 min and then to introduce an 10 Fr duodenal tube, achieving around 70% success.

Other techniques have reached similar results and bedside introduction of gastric or duodenal tubes has been widely proposed, even in pregnant women suffering from hyperemesis gravidarum. More invasive techniques using endoscopy or fluoroscopy are also successful. Techniques using electromagnetic localisation or special antiperistaltic tubes have also some success. Any duodenal tube introduction has to be confirmed by an Xray.
2.3. Prevention and Handling of Current Problems of Enteral Feeding

Once enteral nutrition has been initiated, several adverse events commonly occur, sometimes discouraging or impeding adequate delivery of enteral feeds. Some of the frequently asked questions are shown below. Suggested solutions are also shown (Table 3), although standardisation is lacking in this area. Although the guidelines listed in this chapter are not evidence-based and are open to debate, they reflect current practice in several ICUs in Europe and, with minor alterations, could realistically be adopted by most ICUs worldwide.

Table 3
Troubleshooting common problems related to enteral nutrition

<table>
<thead>
<tr>
<th>Problem</th>
<th>Suggested solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>High gastric residual volume</td>
<td>Could be neglected up to 500 mL. Try to decrease opiates and noradrenaline use</td>
</tr>
<tr>
<td>Prevention of inhalation pneumonia</td>
<td>Constant infusion&lt;br&gt;Flush the catheter after administration of drugs, to prevent occlusion. Elevate head: keep the patient in semi-recumbent position</td>
</tr>
<tr>
<td>Prevention of sinusitis/nasal erosions</td>
<td>Frequent mouth washing&lt;br&gt;Use small tubes, preferentially of silicon</td>
</tr>
<tr>
<td>Diarrhoea</td>
<td>Exclude infectious diarrhoea&lt;br&gt;Decrease infusion rate by half and give loperamide&lt;br&gt;Replace by a fibre-enriched solution and add probiotics . Always check for PMC</td>
</tr>
<tr>
<td>Constipation</td>
<td>Replace by a fibre-enriched solution. Treat when more than 5 days</td>
</tr>
<tr>
<td>Oral drug administration</td>
<td>Avoid long-acting medications, use liquid formulas in preference&lt;br&gt;Crunch and mix pills, rinse the tube with water after administration</td>
</tr>
<tr>
<td>Keeping a nasogastric tube in place when oesophageal erosions have been seen by an endoscopist</td>
<td>Unless responsible for significant bleeding, a small-calibre feeding catheter can be left in place</td>
</tr>
<tr>
<td>Is stress ulcer prophylaxis useful during enteral nutrition?</td>
<td>Although intragastric administration of enteral nutrition partially prevents the occurrence of mucosal erosions and gastrointestinal bleeding, the efficacy of enteral nutrition alone for stress ulcer prophylaxis is not proven. At present, pharmacological stress ulcer prophylaxis should be administered independently from enteral nutrition</td>
</tr>
</tbody>
</table>

2.3.1. Administration Technique

Drip feeding is preferred to bolus feeding (no more that 500 mL per bolus or 30 mL/min). This technique requires intensive nursing observation and gastric residue analysis every 4 to 8 hours (17).
Continuous enteral feeding decreases the GIT secretions and is best achieved using volumetric pumps.
Practical recommendations include a positioning of the head of the bed in an elevated position of 30 degrees (18), (See Table 18.3.2) introduction initially of a nasogastric...
tube, checking the residue and starting with rates of 40-50 mL/h and a concentration rate of 1 kcal/ml. Increase to 75-100 mL/h after a few hours if the solution is isotonic. In the case of failure in achieving gastric emptying, try prokinetic agents and in the case of failure, the introduction of a nasoduodenal tube can be considered, according to the local practice. The administration rate of enteral feeding is slower, starting from 25 mL/h. In the case of high viscosity of the formula, or of obstruction risk, routine extra flushing with a saline solution should be a standard technique to prevent obstruction.

2.3.2. Complications

The complications (18) most encountered are clogging, aspiration pneumonia, vomiting and oesophagitis. Abdominal pain and diarrhoea are also encountered. When hypertonic enteral solutions are used, hyperosmolality and dehydration can occur. Increase in glucose load can induce glucose intolerance and hepatic steatosis, with an increase in alkaline phosphatase, gamma glutamyl transferase and sometimes total and direct bilirubin.

In ventilated patients, the gastric motility is decreased. This is further decreased when morphine or norepinephrine are used.

2.3.2.1. Gastro-duodenal Dysfunction

A common concern during enteral feeding is delayed gastric emptying (19). This condition is defined by an increased gastric residue of more than 500 mL/h, or more than double the administration of the previous hour, or more than 600 mL for the past 24 hours. Studies have shown however that this documentation of gastric residue is not reliable enough to evaluate gastric emptying adequately. A recent study has even demonstrated that not measuring gastric residue had the same outcome as measuring it (20). Other tests such as the sophisticated isotope techniques or the paracetamol absorption test (21) have been proposed to evaluate gastric motility at the bedside. If gastric paresis is observed, it should prompt evaluation of the gastric emptying function. Although there is no clear consensus on the management of gastro-duodenal dysfunction, one should remember that the infusion of enteral feeding is beneficial for the gut mucosa, even at a low rate. Therefore, enteral infusion should not be discontinued, and pro-kinetic drugs should be used when the patient cannot tolerate “a low delivery rate” of enteral feeding. Importantly, once the gastric residual volume is below the cut-off value, the administration rate should be restored to a higher value. An example algorithm is shown in Fig.1.
Many studies have tested the use of metoclopramide 10 to 20 mg, or erythromycin, prior to postpyloric tube placement in medical, surgical and mixed populations. The rate of success was significantly better in 3 out of the 6 studies included here (rates of success of 61% up to 96%) (20).

High gastric residue is not always a sign of poor gastric peristalsis. Cohen et al (21) demonstrated that half of the patients with gastric residue larger than 200 mL had normal gastric emptying demonstrated by the paracetamol test. This easily achieved bedside test can be proposed to help in the decision as to whether to continue gastric enteral feeding administration, to propose a nasojejunal tube, or to think about endoscopic or radiologic positioning.

If the patient is due to receive enteral feeding for more than 3–6 weeks and will require longer enteral support, percutaneous endoscopic gastrostomy should be considered. If
the patient is undergoing abdominal surgery, the relative indications for jejunostomy should be considered. Additional help can be obtained using prokinetic agents that increase gastric peristalsis and gastric emptying. In the case of difficult insertion of a nasoduodenal tube, erythromycin in a single dose may be proposed and facilitate the tube insertion (22). Prokinetic agents have shown positive effects on gastrointestinal transit and feeding in most of the studies, but without showing positive effects on clinical outcome. When comparing between erythromycin, metoclopramide and cisapride, metoclopramide has been found to be the safest, increasing gastrointestinal transit and the tolerance to feeding. Use of erythromycin raised the question of inducing bacterial resistance, and cisapride has now been withdrawn from the market after it was reported to increase QT interval and induce cardiac toxicity in children. However, metoclopramide and erythromycin exert synergistic effects and can be used together in difficult cases.

2.3.2.2. Diarrhoea

Diarrhoea is another common complication of enteral feeding and is actually the most frequent cause of interruption of enteral feeding (22). When diarrhoea is defined as the emission of three or more liquid stools per day, its incidence in critically ill patients ranges from 20% to 50%. In most cases, the continuation of enteral nutrition can be achieved using a systematic and standardized approach. However, when the volume of diarrhoea nonetheless exceeds 350 mL per day, parenteral nutrition should be proposed. The causes of diarrhoea during enteral feeding can be divided into two broad categories: infectious and non-infectious. Standard treatments for infectious diarrhoea associated with *Clostridium difficile* include oral/enteral metronidazole and vancomycin. In most of the cases, diarrhea is not related to enteral feeding which can be continued while antibiotic therapy should be as short as possible.

2.3.2.3. Constipation

Although frequent in patients fed enterally, constipation is not a typical feeding-related complication, but is probably related to a prolonged period in the supine position. However, if untreated, constipation can contribute to ileus, increase abdominal pressure and ultimately impair respiratory function and weaning from the ventilator. Fibre-enriched solutions are usually recommended in cases of constipation, and become progressively a standard of care in the ICU. Enemas should be prescribed if constipation exceeds 5 days (23).

3. Parenteral Nutrition

Parenteral nutrition (PN) is recommended if enteral nutrition is contraindicated or if enteral nutrition does not satisfy energy requirements (7). Access can be central or peripheral. Central access is preferred in ICU patients, who most likely require a central venous catheter anyway for other purposes (central venous pressure monitoring, fluid and vasopressor administration, etc.); in this case, subclavian access is preferred because it is associated with the lowest rates of complications, but also internal jugular or, less frequently, femoral (because of the increased infection risk) veins could be used. Parenteral nutrition should be administered via a separate lumen of a multilumen central catheter, to prevent incompatibilities or physicochemical interactions. Aseptic technique and continued aseptic care of central lines for any purpose are mandatory. For long term PN or for home PN, catheters with implanted ports or subcutaneous tunnelling are used (Broviac, Hickmann, etc.). Peripherally inserted central catheters (PICCs) are more often used for patients requiring PN outside ICU (e.g. on the surgical ward), but recently also in ICU chronically ill patients. If PN is required for a shorter period of time (4-5 days to a maximum of 14 days), peripheral venous access (changed every 48 hours) could be used, but is not preferred. In order not to damage the peripheral vein, the administered solutions should have an
osmolarity <900 mOsm/L, therefore larger volumes of fluids are required to administer the whole nutrition target. Alternatively, this could be used as a safe route for supplemental PN, when the patient requires combined enteral and parenteral nutrition.

To avoid undernutrition, mainly in malnourished patients a diagram is proposed (Fig. 2) proposing to administer parenteral nutrition within 3 days in malnourished patients not able to match at least 50% of their resting energy expenditure at day 3 (24). In non malnourished patients enteral feeding is started and if not reaching the calorie target (80% of the prescription), supplementary parenteral nutrition should be considered to match the caloric debt.

Protein/amino acid administration should aim to reach the 1.2 to 1.5 g/kg/day target within days after admission.

![Fig. 2 Avoiding underfeeding in critically ill patients. From (24) Weimann and Singer Lancet 2013](image)

**3.1 Complications of Parenteral Nutrition**

These are related to:

- Insertion (pneumothorax, arterial, venous or nerve puncture)
- Infection: this can be located at the catheter site, the subcutaneous tunnel, the catheter extremity, or in the blood. CRS (catheter related sepsis) is a frequent cause of sepsis in critically ill patients and requires blood and hub cultures, and replacement of the catheter in case of fever and high suspicion of CRS (24). New catheters impregnated with antiseptic products have been proposed to reduce the prevalence of catheter related sepsis.
• Metabolic complications: these can be acute or long term. Hyper- or hypoglycaemia are the most frequent acute metabolic disturbances encountered. Tight glucose control has become a recommended therapy in critically ill patients. The most feared acute metabolic complication is **refeeding syndrome**; this is discussed elsewhere (see module 18.1). Electrolyte disturbance is diagnosed easily by regular laboratory tests. Hepatic function test disturbances can be found in up to 55% of patients receiving PN (25). A reduction in lipid emulsion load is often a sufficient step to improve the liver blood tests. Additional fish oil supplemented parenteral nutrition is also helpful (see section 18.2) to prevent increased liver function tests. Triglycerides and cholesterol should be monitored and especially so if propofol is used in addition (26).

• Thrombosis: mostly encountered in PVC catheters, venous thrombosis or catheter occlusion are also associated with catheter misplacement and use of hyperosmolar solutions. The diagnosis is suspected when no blood reflux can be obtained and is confirmed by Doppler studies. Catheter fibrinolysis, catheter removal and/or systemic anticoagulant therapy are usually indicated. The use of polyurethane or silicon catheters can prevent these complications.

The appropriate management of PN should aim to detect and treat all complications associated with this type of feeding. The most frequent complications (catheter-related or metabolic/hepatobiliary) and their specific management are listed in **Table 4**.

### Table 4
Parenteral nutrition complications and specific management

<table>
<thead>
<tr>
<th>Catheter-related</th>
<th>Metabolic and hepatobiliary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumothorax/haemothorax</td>
<td>Hyper-/hypoglycaemia</td>
</tr>
<tr>
<td>Catheter misplacement or torsion</td>
<td>Hypertriglyceridaemia /macrophage activation syndrome</td>
</tr>
<tr>
<td>Thrombosis or occlusion</td>
<td>Electrolytic disturbances</td>
</tr>
<tr>
<td>Infection</td>
<td>Steatosis</td>
</tr>
<tr>
<td></td>
<td>Cholestasis</td>
</tr>
<tr>
<td></td>
<td>Acalculous cholecystitis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type</th>
<th>Risk factors</th>
<th>Diagnosis</th>
<th>Prevention</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumothorax Haemothorax</td>
<td>Subclavian puncture</td>
<td>Chest X-ray</td>
<td>Insert thoracic drain</td>
<td></td>
</tr>
<tr>
<td>Catheter misplacement or torsion</td>
<td>Internal jugular puncture</td>
<td>Chest X-ray</td>
<td>Remove the catheter</td>
<td></td>
</tr>
<tr>
<td>Venous thrombosis Catheter occlusion</td>
<td>PVC catheters</td>
<td>Inflammation and/or swelling (local/homolateral arm)</td>
<td>Use polyurethane or silicon catheters</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Catheter misplacement Hyperosmolar solutions</td>
<td>No reflux</td>
<td>Transparent dressings</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pulsed Doppler</td>
<td>Use 0.22 micron filters</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Remove the catheter</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Systemic anticoagulant therapy or catheter fibrinolysis</td>
<td></td>
</tr>
<tr>
<td>Hyperglycaemia</td>
<td>Rate of glucose infusion &gt; 4 mg/kg.min⁻¹</td>
<td>Provide calories as a glucose + lipid mixture Check glycaemia every 4 hours</td>
<td>Reduce glucose supply (2–4 mg/kg.min⁻¹) Intensive insulin therapy</td>
<td>Insulin and reduce carbohydrate load if possible, replacing it with fat</td>
</tr>
<tr>
<td>Hypoglycaemia</td>
<td>Abrupt withdrawal of</td>
<td>Check glycaemia</td>
<td>Re-infuse glucose</td>
<td>Provide continuous</td>
</tr>
<tr>
<td>Condition</td>
<td>Treatment</td>
<td>Monitoring</td>
<td>Prevention/Management</td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>dextrose administration</td>
<td>Excessive insulin therapy</td>
<td>every 4 hours solution</td>
<td>glucose infusion</td>
<td></td>
</tr>
<tr>
<td>Hypertriglyceridaemia</td>
<td>Excessive lipid supply (&gt;4–6 g/kg.day⁻¹)</td>
<td>Check plasma triglycerides 1–2 times/week</td>
<td>Macrophage activation syndrome</td>
<td></td>
</tr>
<tr>
<td>Cholestasis</td>
<td>Absence of oral alimentation Sepsis</td>
<td>Check liver tests 2–3 times/week</td>
<td>Interrupt PN Re-start oral nutrition as soon as possible Use olive oil or fish oil based lipid emulsions</td>
<td></td>
</tr>
<tr>
<td>Steatosis</td>
<td>High caloric supply</td>
<td>Avoid excessive caloric supply. Check liver tests 2–3 times/week</td>
<td>Interrupt PN Hepatic failure</td>
<td></td>
</tr>
<tr>
<td>Acalculous cholecystitis</td>
<td>Fasting Intra luminal microbial overgrowth</td>
<td>Check liver tests 2–3 times/week</td>
<td>Encourage enteral feeding</td>
<td></td>
</tr>
</tbody>
</table>

4. Summary

Critically ill patients, by definition, have increased caloric and protein needs. The administration of an appropriate amount of nutrients by the oral or enteral route is preferred over a parenteral infusion. Additionally, gut protective effects of early enteral feeding have been consistently shown in mechanically ventilated patients. However, significant barriers can impede the enteral administration of nutrients, including gastroduodenal dysfunction reflected by high gastric residual volumes, and diarrhoea and constipation. Possible solutions are suggested. In case of contraindication or failure of enteral nutrition, parenteral nutrition is indicated. It could be used as a replacement or a supplement to failing enteral feeding. The perfect timing of supplemental parenteral nutrition (early or late) remains uncertain, and parenteral nutrition should be carefully monitored.

5. References


