Nutritional support in the intensive care unit

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Nutritional assessment of companion animals is considered to be the fifth vital sign and nutritional support is an important aspect of care for animals in the intensive care unit (ICU). Malnutrition can develop quickly, even in adequately nourished but critically ill animals, and typically results from the type, severity and metabolic demands of the disease affecting the animal, demands from healing, and rapid fluid and electrolyte shifts, which could potentially result in deficiencies in micronutrients such as potassium and magnesium, and loss of specific vitamins and minerals. Adequate nutritional support can preserve lean body mass, facilitate wound healing, reverse the maladaptive metabolic response to injury, maintain organ function and reduce morbidity in critically ill animals. However, nutritional support, whether administered enterally or parenterally, can result in mechanical, infectious and metabolic complications. Therefore, the aims of nutritional support in the ICU include preserving lean body mass, correcting or preventing macro- or micronutrient deficiencies and preventing complications associated with the provision of nutritional support. This article discusses the whole procedure of nutritional intervention, from deciding which route to use to the selection of diets that can be fed and the support required for specific diseases and conditions.

Nutritional assessment

An adequate history, physical examination and minimum laboratory database can help provide information on the nutritional status of a patient, as well as help to determine the best route and type of dietary intervention.

History

A dietary history should be obtained for every animal, comprising documenting the number of days of anorexia or hyporexia, the amount, exact name and formulation of diet typically fed, and any strategies that have been implemented to entice the animal to eat, including the use of appetite stimulants. It is also important to document whether the animal has any comorbidities, such as liver disease, intestinal disease, pancreatitis or kidney disease, for which a commercial therapeutic diet is used, as the same nutritional strategies may need to be considered when the animal is fed in hospital.

Physical examination

Determining cardiovascular, respiratory and hydration status is the first priority when performing a physical examination in a critically ill animal. Once the animal has been stabilised, a more thorough physical examination to identify additional abnormalities and assess nutritional status can be carried out.

Body condition score

Assessing bodyweight as well as nutritional trends is not only important for nutritional assessment, but may also provide prognostic information (Baez and others 2007, Finn and others 2010). However, fluid shifts in critically ill animals may make it difficult to assess and monitor bodyweight accurately so determining body condition score (BCS) can help provide a more accurate idea of a patient’s nutritional status. The BCS gives an indication of the extent of fat coverage but gives no information on muscle mass. A nine-point scale for assessing BCS in companion animals [for dogs: WSAVA 2016a; for cats: WSAVA 2016b], with 1 representing emaciation and 9 obesity, has been validated using dual-energy x-ray absorptiometry and has good interobserver variation (Laflamme 1997a, b). Using this scale, a BCS of 4 to 5 is considered ideal in dogs, with 5 being ideal in cats (Laflamme 1997a, b).

Muscle mass

Adequate muscle mass is typically an indication of adequate protein intake and reserve. I assess muscle mass based on the WSAVA Global Nutrition Committee recommendations [for dogs: WSAVA 2016a; for cats: WSAVA 2016b]. Loss of lean body mass can be due to disuse atrophy, ageing (sarcopenia) and protein energy malnutrition due to critical illness (cachexia) (Freeman 2012). Cachexia is a negative prognostic indicator and reversal of the underlying disease process is the mainstay of treatment (Freeman 2012), although in people increasing dietary protein can help to reverse the process (Op den Kamp and others 2009).

Currently, no information exists on the exact protein requirements of cachectic animals.

Skin and coat quality

Poor skin and coat quality can result from reduced protein intake, as well as a reduction in other essential nutrients such as linoleic acid, zinc, copper, vitamins A and E, riboflavin and biotin (Watson 1998).

Wound healing

Poor wound healing may also be an indication of inadequate nutritional intake (Crane 1989).

Minimum laboratory database

A minimum database consisting of a packed cell volume (PCV), total solids and blood gas analysis with electrolytes should initially be collected in every critically ill animal. However, although the PCV, total solids and some electrolytes such as potassium can be an indication of nutritional status (Phang and Aeberhard 1996), they may be poor markers as they can also be influenced by coexisting factors such as the disease process or excess losses.

Nutritional intervention

Assessment and correction of any cardiovascular, fluid and electrolyte abnormalities is critical before proceeding with nutritional intervention.

Timing

Three to five days of anorexia, either before or during hospitalisation, is an indication for nutritional intervention. However, support may be started sooner in animals that are less than six months of age, older and debilitated, or severely cachetic, or if the anticipated period of anorexia will be protracted due to the underlying disease. Nutritional intervention should also be considered sooner in obese cats due to their increased risk for hepatic lipidosis.

Route

Assisted feeding can occur enterally or parenterally, although enteral feeding is prioritised whenever possible to preserve the intestinal barrier and prevent intestinal atrophy, bacterial translocation and sepsis (Alveryd 1994).

Enteral nutrition

Enteral-assisted feeding consists of either providing food directly into the oral cavity using a syringe or placing a feeding tube (I do not recommend assisted oral feeding with...
a syringe due to the risk of aspiration and food aversion). There are four common types of enteral-assisted feeding tubes used in companion animals (Table 1, Figs 1, 2):

- Nasoenteral;
- Oesophagostomy;
- Gastrostomy (G tube);
- Jejunostomy (J tube).

Ensuring adequate mentation and the presence of a gag reflex is important if this route is to be considered. However, the presence of petechia, ecchymosis, bruising or bleeding on physical examination may be consistent with a thrombocytopenia, thrombocytopenia or a primary or secondary coagulopathy which could be a contraindication to the placement of a tube. Contraindications to sedation or anaesthesia could also preclude enteral feeding.

### Table 1: Characteristics of the four types of enteral feeding tube*

<table>
<thead>
<tr>
<th>Feeding tube</th>
<th>Nasoenteral</th>
<th>Oesophagostomy</th>
<th>Gastrostomy</th>
<th>Jejunostomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical size</td>
<td>5 to 8 French</td>
<td>8 to 19 French</td>
<td>16 to 28 French</td>
<td>5 to 8 French</td>
</tr>
<tr>
<td>Placement</td>
<td>Relatively easy to place, generally using intranasal local anaesthesia</td>
<td>Relatively easy to place under general anaesthesia with minimal equipment</td>
<td>Placed under general anaesthesia using surgery, blind or percutaneous endoscopy techniques</td>
<td>Nasojejunal tube can generally be placed without general anaesthesia or sedation. Gastrojejunostomy and enterostomy tubes require general anaesthesia. Enterostomy tubes can be placed using surgery or laparoscopy</td>
</tr>
<tr>
<td>Length of time used</td>
<td>Three to seven days</td>
<td>Weeks to months</td>
<td>At least 12 months</td>
<td>Duration of hospitalisation [up to 4 weeks in one study] [Novo and others 2001]</td>
</tr>
<tr>
<td>Indications</td>
<td>Anticipated short-term anorexia or anaesthetic risk</td>
<td>Anticipated longer-term anorexia (more than seven days’ duration); mandibular, maxillary, nasal or pharyngeal disease</td>
<td>Anticipated longer-term anorexia (more than seven days’ duration); mandibular, maxillary, nasal, pharyngeal or oesophageal disease</td>
<td>When gastric feeding is contraindicated (e.g., cases of pancreatitis, severe functional or physiological disease of the stomach, delayed gastric emptying, proximal obstruction or intractable vomiting)</td>
</tr>
<tr>
<td>Contraindications</td>
<td>Nasal, oral, pharyngeal or oesophageal disease or trauma; reduced consciousness; protracted vomiting or regurgitation; coagulopathy</td>
<td>Oesophageal disease; coagulopathy, anaesthetic risk; reduced consciousness; protracted vomiting or regurgitation</td>
<td>When gastric feeding is contraindicated (e.g., cases of pancreatitis, severe functional or physiological disease of the stomach, delayed gastric emptying, proximal obstruction or intractable vomiting); coagulopathy, anaesthetic risk, reduced consciousness</td>
<td>Coagulopathy, anaesthetic risk (generally except nasojejunal feeding tube)</td>
</tr>
<tr>
<td>Advantages</td>
<td>Anaesthesia or special equipment are not needed; relatively non-invasive; relatively inexpensive</td>
<td>Light/short anaesthesia needed; relatively easy to place without the need for special equipment; relatively inexpensive; generally well tolerated with only a light neck bandage needed; little danger of serious life-threatening complications if the tube is inadvertently removed before stoma formation; can be maintained by the owner at home</td>
<td>Larger diameter tube allows more dietary options; gastric residual volume can be checked; oesophagus is bypassed if megaesophagus or oesophagitis is present</td>
<td>Avoids stomach, duodenum and pancreas</td>
</tr>
<tr>
<td>Disadvantages</td>
<td>Generally for in-hospital use only; usually short-term use only; may be uncomfortable as an Elizabethan collar is required; the tube may be removed inadvertently by the patient due to vomiting or sneezing; only liquid feedings are possible due to the tube’s small diameter; daily energy requirements are hard to achieve without continuous-rate infusion</td>
<td>General anaesthesia required; there is potential for infection at entry site; the gastric residual volume cannot be checked in cases of suspected ileus</td>
<td>General anaesthesia and specialised equipment are required in some cases; there is a risk of septic peritonitis if the tube is inadvertently removed before stoma formation (before 12 to 14 days); a longer/deeper anaesthetic is needed, which may increase risk and cost</td>
<td>Gastrojejunostomy and enterostomy tubes require general anaesthesia, in-hospital use only and therefore relatively short-term use; specialised liquid diet required due to the tube’s small diameter and location; there is a risk of septic peritonitis if the tube is inadvertently removed before stoma formation (before 12 to 14 days)</td>
</tr>
<tr>
<td>Possible complications</td>
<td>Incorrect placement of the tube resulting in aspiration pneumonia; nasal irritation; obstruction of tube with food or due to kinking; the tube can be removed by vomiting or sneezing</td>
<td>Infection at the entry site; obstruction of tube with food or medication, or kinking; the tube can be removed by vomiting</td>
<td>Septic peritonitis due to tube removal before stoma formation; gastric bleeding during placement; improper tube placement; vomiting; infection or leakage at the entry site; aspiration pneumonia</td>
<td>Septic peritonitis due to tube removal before stoma formation; retrograde tube migration; vomiting/diarrhoea; cellulitis at the entry site; tube obstruction; leakage of gastrointestinal contents</td>
</tr>
</tbody>
</table>

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* Saker and Remillard [2010], Larsen [2012]
into the cephalic vein; the port should not have been used for any purpose before PN administration.

For central administration, the osmolality should not exceed 1400 mOsm/l, whereas the limit for peripheral administration is typically 600 to 750 mOsm/l to help prevent thrombophlebitis (Campbell and others 2006). Due to the constraints of osmolality, it may be difficult to administer the animal’s full daily energy requirement by peripheral PN but, as the lipid component of the PN solution has the highest caloric density, a PN solution containing a high amount of lipid may overcome this. However, some veterinary nutritionists recommend not using more than 2 g lipid/kg bodyweight/day due to the concern for immunosuppression (Chan and Freeman 2006).

### Diet selection

#### Enteral nutrition

The size of the enteral-assisted feeding tube and its location dictate the type of diet that can be fed to a patient.

Feeding via a nasoenteral feeding tube can be the most challenging due to the relatively small diameter of the tube. However, Royal Canin have recently launched a range of complete liquid diets in the UK that can be fed through these tubes for both dogs and cats. These products include a Recovery Liquid formula both for dogs and cats, a Renal Liquid formula for cats, a Renal Liquid formula for dogs, a GL Low Fat Liquid formula for dogs and a GI High Energy Liquid formula for dogs.

Depending on the animal’s disease conditions, a suitable commercial veterinary therapeutic diet can be blended with water to form a slurry that can be administered via an oesophagostomy or gastrostomy feeding tube. Liquidising the dry formula of the diet typically results in a higher caloric density than canned food and can therefore reduce the volume that may need to be administered daily to meet the animal’s energy requirement (Case scenario 1).

Jejunostomy feeding tubes have a small diameter that is comparable in size to that of a nasoenteral feeding tube and can be used to feed specialised human liquid elemental diets to dogs.

### Parenteral nutrition

A PN formulation consists of three main components:

- An amino acid solution;
- A lipid solution;
- A dextrose solution.

PN is not typically used long term so it does not provide all of the animal’s daily nutrient requirements, but some veterinary nutritionists may add certain minerals if administration is likely to exceed five days (Chan and Freeman 2006).

A PN solution is first formulated to meet the patient’s protein requirement. This is determined to provide 3 to 4 g/100 kcal for dogs and 6 g/100 kcal for cats (Chan and Freeman 2006). If the animal has protein intolerance due to kidney disease or liver dysfunction, then the provision of 3 g/100 kcal is recommended for dogs and 4 g/100 kcal for cats (Chan and Freeman 2006). Once the protein requirement is calculated, the remaining non-protein calories are provided by equal amounts (50:50) of lipid and dextrose (Case scenario 2). More than 50 per cent dextrose and an excess of 4 mg/kg/minute of dextrose infusion should be avoided due to potential complications associated with hyperglycaemia, which is also a poor prognostic indicator in dogs and cats (Pyle and others 2004, Torre and others 2007).

Pancreatitis is not an indication to reduce the amount of lipid in the PN solution, as parenteral fat does not stimulate the pancreas (Edelman and Valenzuela 1989). However, the presence of hyperlipidaemia would be an indication to reduce the amount of lipid in the PN solution. As noted above, due to the concern for immunosuppression, lipid administration should not exceed 2 g/kg bodyweight/day.

β-complex vitamins are commonly added to the PN formulation. Electrolytes such as potassium and phosphorus can also be added, but this is usually assessed on a case-by-case basis, as it may be easier to adjust the amount administered if given via intravenous fluids rather than via the PN route.

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**Case scenario 1: Enteral nutrition**

A 5.9 kg, eight-year-old female neutered domestic shorthair cat was diagnosed with hepatic lipidosis secondary to suspected cholangiohepatitis. A 5 French nasoenteral feeding tube was initially placed and Royal Canin Veterinary Diet Recovery Liquid diet administered at 25 per cent of the daily resting energy requirement (RER). This was increased to 50 per cent on day 2. As the animal was stable, a 14 French oesophagostomy feeding tube was placed under general anaesthesia on day 3. Given that the animal had no signs of hepatic encephalopathy or other medical conditions, a commercial therapeutic feline recovery dry food was chosen for feeding via the oesophagostomy feeding tube.

**Calculating the amount of slurry to be fed**

1. Calculate the daily RER: 70 x 5.9 kg = 395 kcal/day

2. Determine the number of calories in 1 g of the chosen diet (this is typically present in the manufacturer’s guide or can be obtained by contacting the company).

For this example, assume it is 3.8 kcal/g of food.

3. Determine the number of days worth of slurry to make. For example, enough for two days can be made and stored in the fridge until used. The slurry can be gently heated to room temperature in a water bath before administration. Two days worth of slurry would be:

\[2 \times 395 \text{ kcal} = 530 \text{ kcal}\]

4. Calculate the amount (g) of diet needed for two days:

\[\text{Total number of calories needed for two days} = \frac{530 \text{ kcal}}{3.8 \text{ kcal/g}} = 139 \text{ g}\]

5. Place 139 g of the diet in a blender, pulverise, add water in 50 ml increments and blend into a slurry until a consistency is reached that will easily pass through the oesophagostomy tube (the consistency of the slurry can be tested by passing a sample through another tube of the same size).

6. Once the desired consistency is achieved, measure the total volume of the two-day batch of slurry. In this example, assume the total volume of slurry is 550 ml. Divide the total number of calories in the diet by the total volume to get the caloric density of the slurry:

\[\frac{530 \text{ kcal}}{550 \text{ ml}} = 0.96 \text{ kcal/ml}\]

7. Calculate the amount of slurry needed to achieve 25 per cent RER, 50 per cent RER, 75 per cent RER and 100 per cent RER.

25 per cent RER:

\[265 \text{ kcal} \times 0.25 = 66 \text{ kcal}\]

\[\frac{66 \text{ kcal}}{0.96 \text{ kcal/ml}} = 69 \text{ ml}\]

50 per cent RER:

\[265 \text{ kcal} \times 0.5 = 133 \text{ kcal}\]

\[\frac{133 \text{ kcal}}{0.96 \text{ kcal/ml}} = 139 \text{ ml}\]

75 per cent RER:

\[265 \text{ kcal} \times 0.75 = 199 \text{ kcal}\]

\[\frac{199 \text{ kcal}}{0.96 \text{ kcal/ml}} = 207 \text{ ml}\]

100 per cent RER:

\[265 \text{ kcal} \times 1 = 276 \text{ ml}\]

\[\frac{276 \text{ ml}}{0.96 \text{ kcal/ml}} = 276 \text{ ml}\]
The PN solution can be compounded under a laminar flow hood using a closed, semi-automated system or manually using an all-in-one system. However, with both techniques, strict adherence to asepsis is paramount. Alternatively, three-in-one solutions are also commercially available.

### Case scenario 2: Parenteral nutrition

A 10 kg five-year-old male neutered mixed-breed dog was presented with intractable vomiting and moderate thrombocytopenia due to acute pancreatitis. The animal had a multilumen central line in place and its serum triglyceride levels were within the normal reference range. The animal had been anorectic for five days. Due to intractable vomiting and moderate thrombocytopenia, central parenteral nutrition (PN) should be initiated.

**Calculating the amount of PN formulation to be fed**

1. **Calculate the resting energy requirement (RER):**
   \[
   \text{RER} = 70 \times 10^{0.75} = 394 \text{ kcal}
   \]

2. **Calculate the daily protein requirement (standard recommendation): 4 to 5 g/100 kcal provided:**
   \[
   (394 \text{ kcal/100}) \times 4 \text{ g/100 kcal provided} = 15.8 \text{ g protein/day}
   \]

3. **Calculate the number of calories of protein required per day (4 kcal/g protein):**
   \[
   15.8 \text{ g protein/day} 	imes 4 \text{ kcal} = 63 \text{ kcal of protein/day}
   \]

4. **Calculate number of non-protein calories required per day:**
   \[
   394 \text{ kcal (RER)} - 63 \text{ kcal (protein required per day)} = 331 \text{ non-protein kcal/day}
   \]

5. **Calculate number of calories of lipid and dextrose required per day (usually provided as a 50:50 mixture of lipid to dextrose. This ratio may need to be adjusted if the dog develops hypertriglyceridaemia or hyperglycaemia):**
   \[
   331 \text{ non-protein kcal, } 166 \text{ kcal of lipid + 166 kcal of dextrose}
   \]

6. **Calculate the volumes of nutrient solutions required per day.**

   **Protein:**
   \[
   8.5 \text{ per cent amino acid solution} = 0.085 \text{ g protein/ml}
   \]

   \[
   0.085 \text{ kcal/ml} \times 4 \text{ kcal} = 0.34 \text{ kcal protein/ml}
   \]

   \[
   63 \text{ kcal protein/day} = 0.34 \text{ kcal/ml} \times 185 \text{ ml of amino acid solution}
   \]

   \[
   0.34 \text{ kcal/ml} = 166 \text{ kcal of lipid}
   \]

   \[
   2 \text{ kcal/ml} = 166 \text{ kcal of dextrose}
   \]

7. **Calculate the total volume of solution (amino acid solution [ml] + lipid solution [ml] + dextrose solution [ml]):**
   \[
   185 \text{ ml} + 83 \text{ ml} + 98 \text{ ml} = 366 \text{ ml}
   \]

8. **Calculate caloric density of solution:**
   \[
   \frac{\text{Total kcal}}{\text{Total PN (ml)}} = \frac{394 \text{ kcal}}{366 \text{ ml}} = 1.08 \text{ kcal/ml}
   \]

9. **Calculate the amount of PN solution needed to achieve 25 per cent RER, 50 per cent RER, 75 per cent RER and 100 per cent RER:**

   - **25 per cent RER:**
     \[
     \frac{394 \text{ kcal} \times 0.25}{100} = 99 \text{ kcal}
     \]

   - **50 per cent RER:**
     \[
     \frac{394 \text{ kcal} \times 0.5}{100} = 197 \text{ kcal}
     \]

   - **75 per cent RER:**
     \[
     \frac{394 \text{ kcal} \times 0.75}{100} = 296 \text{ kcal}
     \]

   - **100 per cent RER:**
     \[
     \frac{394 \text{ kcal}}{100} = 394 \text{ kcal}
     \]

10. **Calculate the amount of water should be syringed into the tube afterwards. If the animal tolerates feeding at 25 per cent RER, this can be increased to 50 per cent on day 2, 75 per cent on day 3 and 100 per cent on day 4 and after.**

     Feeding above the RER is not recommended during hospitalisation due to complications associated with overfeeding (Chan and Freeman 2006).

    As the feedings are increased to the full RER, the animal should be monitored for unknown tolerance in such patients. Bolus feedings should be administered slowly over 20 to 30 minutes while the animal is monitored for any signs of nausea. A small amount of water should be syringed into the tube afterwards. If the animal tolerates feeding at 25 per cent RER, this can be increased to 50 per cent on day 2, 75 per cent on day 3 and 100 per cent on day 4 and after. Feeding above the RER is not recommended during hospitalisation due to complications associated with overfeeding (Chan and Freeman 2006).

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are normalised, the rate of enteral nutrition can be increased by 25 per cent every 12 to 24 hours until 100 per cent RER is reached. It should not exceed 100 per cent RER to avoid complications associated with overfeeding (Chan and Freeman 2006). All PN should be administered through an in-line filter via a constant-rate infusion using an infusion pump.

The patient should be monitored closely for complications during the whole procedure so PN should ideally be administered in the intensive care unit. Each bag of PN solution should not be used for more than 24 to 48 hours, after which it, together with the administration line, should be discarded and a new bag used. Ideally, the bag and line should be covered and protected from light to prevent degradation of certain light-sensitive B vitamins. The bag should be inspected daily to ensure there are no precipitates forming and that the mixture is homogenous. Once the bag is being used, the line should not be disconnected, even for walks or diagnostic testing, and it should always be placed higher than the intravenous catheter. If the animal is also receiving intravenous fluids, the PN rate should be reduced accordingly to prevent overhydration.

Complications

The two most common mechanical complications associated with enteral nutrition include unintentional tube removal and clogging of the tube. NASOenteral feeding tubes can be removed inadvertently by the animal due to sneezing or vomiting. Accidental removal of gastrosotomy or jejunostomy tubes before stoma formation can result in life-threatening septic peritonitis. With such cases, the tube should be immediately clogged. Clogged tubes can be unclogged using warm water, which has been shown to be more effective than carbonated beverages and cranberry juice (Parker and Freeman 2013). Flushing the tube with water after use is important to prevent clogging.

Percutaneous tube site infections can develop when using enteral feeding tubes, particularly oesophagostomy tubes, so diligent monitoring and cleaning of the site daily is recommended to prevent infectious complications.

Box 1: Refeeding syndrome

Refeeding syndrome comprises metabolic derangements that can occur as a result of reinstitution of nutrition to an animal that was previously starved, commonly due to severe illness.

During starvation and illness, the body switches from oxidation of carbohydrates to oxidation of fats and amino acids as the energy source, resulting in minimal insulin secretion. During refeeding, insulin secretion increases in response to increased blood glucose. Insulin causes the movement of glucose intracellularly, together with phosphorus, potassium and magnesium, resulting in a depletion of these electrolytes, together with thiamine. As a result, clinical signs of hypophosphataemia, hypokalaemia, hypomagnesaemia and decreased thiamine may become apparent [Box 2]. Therefore, critically ill animals deemed to be at an increased risk for refeeding syndrome should have electrolytes and the packed cell volume closely monitored during the initiation of nutrition and before each subsequent increase in rate.

Box 2: Clinical signs of hypokalaemia, hypophosphataemia, hypomagnesaemia and decreased thiamine due to refeeding syndrome*

| Hypokalaemia | • Skeletal muscle weakness | • Dyspnoea from paralysis of the respiratory muscles in severe cases |
| Hypophosphataemia | • Ventroflexion of the head and neck | • Cardiac conduction abnormalities such as premature ventricular contractions, ventricular tachycardia (particularly torsades de pointes), fibrillation and supraventricular tachycardia |
| Hypomagnesaemia | • Stiff gait and plantigrade stance | Decreased thiamine |
| • Rhabdomyolysis | • Respiratory paralysis in severe cases | • Altered mentation |
| • Myoglobinuria | • Cardiac conduction abnormalities such as atrial and ventricular tachyarrhythmia, atrioventricular dissociation and ventricular fibrillation |
| • Respiratory failure in severe cases | | • Acute blindness, mydriasis or anisocoria |
| • Haemolytic anaemia | | • Ataxia |
| • Tissue hypoxia leading to ataxia, altered mental status, seizures and coma | | • Proprioceptive deficits |
| | | • Polynuropathy |
| Hypomagnesaemia | • Muscle weakness or fasciculation | • Vestibular signs |
| • Hyperreflexia, ataxia, seizure and coma | | • Ventroflexion of the head and neck |
| * Manning (2001), Markovich and others (2013) |

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Due to concern with intestinal atrophy, bacterial translocation and sepsis with disuse of the gastrointestinal tract, some oral feeding is encouraged so a nasoenteral feeding tube can be placed concurrently for trickle feeding. This involves administering approximately 10 per cent of the animal’s calculated daily RER via continuous-rate infusion through the nasoenteral feeding tube to provide some nutrition to the enterocytes. Once the animal is eating voluntarily or until a more permanent enteral feeding tube can be placed, it can be slowly weaned off PN. PN should not be stopped abruptly because hypoglycaemia may develop due to higher circulating levels of insulin caused by PN.

Complications
Mechanical, metabolic and septic complications are associated with PN.
Mechanical complications may include disconnected lines, a failed catheter or kinking, thrombophlebitis or clogged lines.
Metabolic complications can be divided into overfeeding or refeeding. Overfeeding carbohydrate can result in hyperglycaemia, lipogenesis, hepatic steatosis, cholesterol and increased carbon dioxide, making it difficult to wean the patient off the ventilator (Forbes 2004). Hyperglycaemia is the most common complication associated with PN (Queu and others 2011) and has been shown to be a negative prognostic indicator (Pyke and others 2004). It has also been associated with a longer duration of hospitalisation, a higher risk of infectious complications and a poorer outcome in critically ill dogs (Torre and others 2007). Overfeeding lipid can result in hypertriglyceridaemia, immunosuppression and hepatic steatosis (Mashima 1979; Adamkin and others 1984, Klein and Miles 1994, Granato and others 2000), and overfeeding protein can result in azotaemia (Chan 2004). Refeeding syndrome can also develop in malnourished critically ill patients receiving PN.

Blood glucose, potassium, magnesium, phosphorus, blood urea nitrogen and PCV should therefore be monitored in animals receiving PN, and their serum should be assessed for lipaemia and icterus at least every six to 12 hours while progressing to full RER. Bodyweight and hydration status should be determined at least twice a day. Due to the concern for sepsis, a full physical examination including temperature assessment should be performed twice a day and analysis of a blood smear or a complete blood count should be undertaken every other day. Blood cultures should be considered if indicated clinically. The catheter site should be assessed daily using an aseptic technique.

Effectiveness
Assessment of the effectiveness of PN includes ensuring the animal maintains at least its current bodyweight, BCS and lean body mass, does not develop or have worsening metabolic blood parameters or electrolyte abnormalities, and ideally has improved wound healing and immune function.

Specific diseases and conditions

Trauma
Animals with orofacial trauma should have either an oesophagostomy or gastrostomy tube placed for long-term feeding while the lesions are healing. For animals with other types of trauma (eg, those hit by a car or with an orthopaedic fracture), if short-term anorexia or hypoxia is anticipated or general anaesthesia is contraindicated, a nasoenteral feeding tube can be placed. If a longer period of anorexia or hypoxia is anticipated then a more permanent enteral feeding tube, such as an oesophagostomy tube, can be placed (Table 1). If the animal has no concurrent medical conditions, a commercial veterinary therapeutic recovery or critical illness diet can be used.

Canine pancreatitis
Dogs with acute pancreatitis can present with clinical signs comprising vomiting, diarrhoea, abdominal pain and inappetence (Papa and others 2011). Dietary fat restriction is the main nutritional strategy for management of those cases of canine pancreatitis that were triggered by fat or where the animal has a low tolerance to fat. Inappetent animals with intractable vomiting or diarrhoea, those with a coagulopathy due to the severity of their disease or those that are not good anaesthetic candidates may benefit from PN. However, if enteral feeding can be initiated, this is the preferred route. If a patient’s vomiting can be controlled with the use of antimetics and its coagulation status is normal but it is not a good anaesthetic candidate, a nasoenteral feeding tube can be placed and a human or veterinary liquid enteral diet, such as Royal Canin GI Low Fat Liquid, can be administered temporarily. Once the animal is eating, a commercial veterinary therapeutic reduced fat diet can be offered. If the animal is stable for general anaesthesia and vomiting is controlled, an oesophagostomy tube can be placed for long-term feeding, if needed, and a commercial veterinary therapeutic reduced fat diet can be administered via the tube. IPPN is required, the fat content of the solution does not need to be decreased unless the animal has concurrent hypertriglyceridaemia.

Feline hepatic lipidosis
Obese cats have an increased susceptibility to hepatic lipidosis following prolonged anorexia of any cause. Active feeding should be instituted as soon as possible following hospitalisation to try to reverse the metabolic derangement. A nasoenteral feeding tube is typically placed while the animal is stabilised and feeding is initiated with Royal Canin Recovery Liquid at no more than 25 per cent RER, especially as these animals may be susceptible to refeeding syndrome (Brenner and others 2011). Once the animal has been stabilised and initial diagnostics have been performed to determine the cause of anorexia, the animal can be anaesthetised for placement of a longer-term feeding tube as the period of anorexia is usually protracted in such cases. Once an oesophagostomy or gastrostomy tube has been placed, feeding can be initiated using a commercial veterinary therapeutic recovery diet unless the animal has a concurrent condition for which a specific dietary strategy would be needed (eg, kidney disease or inflammatory bowel disease). Dietary protein should be reduced if the animal has evidence of hepatic encephalopathy.

Food should not be offered to these animals for voluntary consumption during hospitalisation as this may cause nausea and lead to food aversion. Once the animal is discharged to the care of the owners, food can be offered at home for oral consumption.

Supplementation in hospital with oral vitamin E (10 iu/kg/day), oral thiamine (100 mg/day), oral taurine (250 mg/day for the first seven to 10 days), oral carnitine (250 mg/ day), subcutaneous vitamin K (0.5 to 1.5 mg/kg every 12 hours for two to three doses) and subcutaneous vitamin B12 (500 to 1000 µg once a week for six weeks, then adjust the frequency based on repeat blood level testing) has been recommended by some authors (Center 2005). Hypokalaemia is associated with a poor prognosis in cats with hepatic lipidosis (Center and others 1993), so serum potassium should be monitored regularly and intravenous or oral supplementation initiated as needed.

Kidney disease
Animals with critical illness due to acute kidney injury or advanced chronic kidney disease can present with uraemia, which can result in anorexia, oral ulcers, vomiting, diarrhoea and weight loss (Elliott and Barber 1998, O’Neill and others 2013). If the animal does not eat voluntarily, placement of an enteral feeding tube should be considered. However, general anaesthesia may be contraindicated in these animals depending on the severity of their disease. Therefore, a nasoenteral feeding tube can be placed and Royal Canin Renal Liquid for dogs and Royal Canin Renal Liquid for cats can be fed to dogs and cats, respectively. If the animal is stable for general anaesthesia, an oesophagostomy or gastrostomy tube can be placed for long-term feeding.

Many commercial veterinary therapeutic renal dry food diets can be liquefied with water to form a relatively calorifically dense slurry for long-term feeding.

Intestinal disease
Severe gastroenteritis resulting in intractable vomiting and diarrhoea may be an indication for PN. If these clinical signs can be controlled, a nasoenteral feeding tube can be placed if the period of hypoxia or anorexia is anticipated to be short term, or an oesophagostomy tube placed if the return of an adequate appetite is anticipated to be protracted.

Royal Canin GI Low Fat Liquid or Royal Canin GI High Energy Liquid can be offered to dogs in the short term via a nasoenteral feeding tube. For cats, Royal Canin Recovery Liquid can be used for short-term use. If an oesophagostomy tube is present, either a commercial veterinary therapeutic hydrolysed diet, limited ingredient novel protein diet or highly digestible...
gastrointestinal diet can be blended with water and fed via the tube, depending on the suspected underlying aetiology.

References

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Nutritional support in the intensive care unit

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