Making a difference - nutritional support in critically ill patients

Daniel Chan, DVM, Dipl. ACVECC, Dipl. ACVN, FHEA, MRCVS
Royal Veterinary College, University of London, UK

Dr. Chan graduated from Cornell University in 1998 and completed a small animal internship at the Animal Medical Center in New York City before embarking on a dual residency in Emergency and Critical Care and Clinical Nutrition at the Cummings School of Veterinary Medicine - Tufts University. He is currently a Senior Lecturer in Emergency and Critical Care and Clinical Nutritionist at the Royal Veterinary College in the UK, where he co-directs the Emergency and Critical Care Section as well as serving as head of the Nutritional Support Service. Dan is also Editor-in-Chief of the Journal of Veterinary Emergency and Critical Care.

Introduction
For many years, the major controversy surrounding critical care nutrition was in fact “do critically ill patients actually need nutrition?” In years past (and perhaps even today) provision of nutrition to such patients typically received a very low priority. This problem was later described as “in-hospital starvation” and is most common in the care of elderly human patients (1). When the effects of malnutrition on patient morbidity and mortality were realized, a reactive movement ensued in critical care in the 1970’s which coincided with the development and adoption of parenteral nutrition; many patients were fed quite aggressively, leading to the term “hyperalimentation”. It was later determined that such an approach, whereby patients received calories well in excess of their needs, led to its own set of complications (2,3). Much like other aspects of critical care, our paradigm of critical care nutrition constantly changes; previously held assumptions become less relevant and new research uncovers novel strategies.

Nutritional support is now considered essential for the recovery of post-operative, critically ill, and injured human patients. Whilst there is convincing evidence of the deleterious effects of malnutrition in people (4,5) the optimal nutritional strategies for critically ill and post-operative animals remain controversial and are largely unknown (Figure 1). Because malnutrition imparts similar metabolic effects in animals, it is assumed that nutritional support is equally essential for the recovery of critically ill dogs and cats. Although definitive answers regarding the impact of nutritional support on outcome in critically ill animals are lacking, some encouraging results suggest that outcome in hospitalized animals can be enhanced with nutritional support (6-8). From these emerging advancements in veterinary nutrition, and our current understanding of metabolic response to injury, we are beginning to formulate recommendations for the nutritional management of critically ill animals. In fact, with proper patient selection, sound nutritional planning, and careful monitoring, nutritional support can be an integral part in the successful recovery of many critically ill animals.
Pathophysiology of malnutrition

One of the major metabolic alterations associated with critical illness involves body protein catabolism, in which protein turnover rates may become markedly elevated (9,10). Whereas healthy animals primarily lose fat when deprived of sufficient calories (simple starvation), sick or traumatized patients catabolize lean body mass when they are not provided with sufficient calories (stressed starvation). During the initial stages of fasting in the healthy state, glycogen stores are used as the primary source of energy. Within days, a metabolic shift occurs towards the preferential use of stored fat, sparing catabolic effects on lean muscle tissue. In diseased states, the inflammatory response triggers alterations in cytokines and hormone concentrations and rapidly shifts metabolism towards a catabolic state. Glycogen stores are quickly depleted, especially in strict carnivores such as the cat, and this leads to an early mobilization of amino acids from muscle stores. As cats undergo continuous gluconeogenesis, this amino acid mobilization is more pronounced than that observed in other species. With continued lack of food intake, the predominant energy source is derived from accelerated proteolysis (muscle breakdown), which in itself is an energy-consuming process. Muscle catabolism that occurs during stress provides the liver with gluconeogenic precursors and other amino acids for glucose and acute-phase protein production. The resultant negative nitrogen balance or net protein loss has been documented in critically ill dogs and cats (11); one study estimated that 73% of hospitalized dogs (including post-operative patients) evaluated in four different veterinary referral centers were in a negative energy balance (12).

The consequences of continued lean body mass losses include negative effects on wound healing, immune function, strength (both skeletal and respiratory muscle strength), and ultimately on overall prognosis. In the context of post-operative patients, this could lead to greater risk of surgical wound dehiscence and post-operative infections (10). Due to the metabolic alterations associated with critical illness, and in part due to an inability or reluctance of many critically ill and post-operative animals to ingest sufficient calories, this patient population is at increased risk for rapid development of malnutrition. Given the serious sequelae of malnutrition, preservation or reversal of deteriorating nutritional status via nutritional support is paramount to minimize the impact of malnutrition and enhance the recovery rate.

Anorexia for as little as 3 days can produce metabolic changes in dogs consistent with those associated with starvation in people (13). However, these dogs would not necessarily exhibit any easily detectable abnormalities on clinical assessment suggestive of being malnourished. Dogs with overt signs suggestive of malnutrition usually have a more protracted period (usually weeks to months) of disease progression. Healthy cats subjected to acute starvation have detectable immune impairment by day 4 and so recommendations to institute some nutritional support in any ill cat that has had inadequate food intake for more than 3 days have been made (14). In both dogs and cats, there is some consensus that there is an urgent need to implement nutritional intervention (e.g. placement of a feeding tube) when an animal has not eaten for more than 5 days. The optimal timing of implementing parenteral nutrition in malnourished human patients is currently controversial (15); in animals, recommendations center on the inability to feed enterally, and in most veterinary studies parenteral nutrition has been initiated within the first 4 days of hospitalization.

Nutritional assessment and planning

An important factor related to successful management of the critically ill patient involves both selection of animals most likely to benefit from nutritional support and selection of the most appropriate route for providing nutrition. Some animals, e.g. obese cats (at risk for hepatic lipidosis) or growing animals may benefit from early intervention. Nutrition via a functional digestive system is the preferred route of administration, and so particular care should be taken to evaluate if the patient...
can tolerate enteral feedings. Even if a patient can tolerate only small amounts of enteral nutrition, this route should be pursued. Supplementation with parenteral nutrition should occur only when enteral feeding cannot meet at least 50% the patient’s nutritional needs. On the basis of the nutritional assessment, the anticipated duration of nutritional support, and the appropriate route of delivery (i.e. enteral or parenteral), a plan is formulated to meet the patient’s nutritional needs.

First steps in instituting nutritional support include restoring proper hydration status, correcting electrolyte or acid-base disturbances, and achieving hemodynamic stability. Commencing nutritional support before these abnormalities are addressed can increase the risk of complications and, in some cases, can further compromise the patient (16). It should be emphasized that this is not counter to the concept of “early nutritional support”, which has been documented to result in positive effects in several animal and human studies. Early nutritional support advocates feeding as soon as possible after hemodynamic stability is achieved, rather than delaying nutritional intervention by several days (17).

■ Calculating nutritional requirements

The patient’s resting energy requirement (RER) is the number of calories required for maintaining homeostasis while the animal rests quietly. The RER is calculated using the following formula:

\[ RER = 70 \times \text{(body weight in kg)}^{0.75} \]

For animals weighing between 2 and 30 kg, the following linear formula gives a good approximation of energy needs:

\[ RER = (30 \times \text{body weight in kg}) + 70 \]

Traditionally, the RER was then multiplied by a subjective “illness factor” between 1.0-1.5 to account for increases in metabolism associated with different conditions and injuries. Recently, there has been less emphasis on this factor, and current recommendations are to use more conservative energy estimates to avoid overfeeding. Overfeeding can result in metabolic and gastrointestinal complications, hepatic dysfunction, increased CO₂ production, and weakened respiratory muscles. Of the metabolic complications, the development of hyperglycaemia is most common, and possibly the most detrimental.

Currently, the RER is used as an initial estimate of a critically ill patient’s energy requirements. It should be emphasized that these general guidelines should be used as starting points, and animals receiving nutritional support should be closely monitored for tolerance of nutritional interventions. Continual decline in bodyweight or body condition should prompt the clinician to reassess and perhaps modify the plan (e.g. increasing the number of calories provided by increments of 25%).

■ Implementing the nutritional plan

To implement enteral nutritional support, a feeding tube is typically required. Placement of a tube is recommended whenever voluntary eating by the patient is lacking in sufficient amounts to meet at least 75% of RER. Considerations for selecting one tube over another should take into account the degree of nutritional support required, the expected duration of support, and the segment of the gastrointestinal tract that must be bypassed as well as other factors such as cost and whether or not sedation/anesthesia is required. Once a feeding tube is in place, a diet preparation that is suitable to meet the nutritional needs of the patient and appropriate for the tube is chosen. Small-bore tubes such as those typically used for nasoesophageal placement, or jejunostomy tubes, require complete liquid diets. Gruel-type diets require larger-bore esophageal or gastrostomy tubes and the preparation of these diets may require the use of a kitchen blender. Other considerations for choosing a diet include fat content, protein content, and caloric density of the food (taking into account the effect of dilution if water is added to the preparation). The next consideration involves the manner in which food is delivered; animals with nasoesophageal, esophagostomy, and gastro-
Stomach tubes tolerate bolus feedings in which the prescribed amount of food is administered over 15 minutes up to every 4 hours. Animals with jejunostomy tubes are usually fed via constant rate infusions.

### Meeting nutritional needs

There is much that remains unclear regarding the nutritional requirements of critically ill animals in general. In certain circumstances assumptions are made that nutritional requirements in animals are comparable to people afflicted with similar diseases. However, it is important to recognize that there may be significant species and disease differences that make direct comparisons or extrapolations less applicable. Experimental data suggests dramatic changes in energy requirements in animals with thermal burns, but there are virtually no clinical data to support this notion. Studies in dogs with thermal burns showed increased energy requirements, accelerated gluconeogenesis, glucose oxidation, lipolysis and increased amino acid oxidation (18). In the absence of definitive data to suggest otherwise, current recommendations are to start nutritional support as soon as it is deemed safe and initially target the RER, but to reassess the patient continually as energy requirements may be more than twice the calculated figure. The goal of nutritional support is to optimize protein synthesis and preserve lean body mass; feeding at least 6-7 g protein per 100 kcal (25-35% of total energy) may be necessary for both dogs and cats. During hospitalization, regaining normal body weight is not top priority, as this should occur once the animal is discharged to complete recovery at home.

Patients with protein intolerance (e.g. hepatic encephalopathy, severe azotemia) should receive reduced amounts of protein. Similarly, patients with hyperglycemia or hyperlipidemia may also require decreased amounts of simple carbohydrates and fat, respectively. Other nutritional requirements will depend upon the patient’s underlying disease, clinical signs, and laboratory parameters.

### When should feeding be initiated?

As alluded to earlier, for many years conventional therapy actually ignored nutritional needs of critically ill human patients. As more and more evidence illustrated the consequences of malnutrition there was a gradual change to ensure that all patients received adequate nutrition. Typical delays in starting nutrition decreased from weeks to 10 days, and now the debate centers on how many hours nutrition should be delayed. As more and more research uncovered the benefits of enteral nutrition and the complications arising from gut atrophy, critical care specialists began feeding patients earlier and earlier in the course of hospitalization with good results (17).

In veterinary medicine a similar transition has occurred in the last 15 years, from the ineffective strategies (such as force- or syringe-feeding, warming foods, adding flavor enhancers) to more recent recommendations for early tube feeding in most, if not all, critically ill patients (19,20). While most can agree that nutritional support is important, and that early intervention is better than delayed, the question remains, how early to intervene? Is it days or hours? The most aggressive approach is to place a feeding tube as soon as possible and startfeedings within hours. Is this necessary? Studies in canine patients with paroviral enteritis, hemorrhagic gastroenteritis and acute pancreatitis support the premise that early nutritional intervention is at least well tolerated and produces few complications (19-21). The lack of any serious consequences to initiating feeding early in these patient populations dispel the myth that

---

Table 1. Practical considerations for tube feeding in dogs and cats.

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Select the diet appropriate for the patient’s condition. Any canned diet can be used; dry diets may also be used but require more water.</td>
</tr>
<tr>
<td>2.</td>
<td>Put a given amount of diet in the blender, and calculate the energy content (in Kcal) it represents using manufacturer’s information.</td>
</tr>
<tr>
<td>3.</td>
<td>If necessary add sufficient water to achieve a blend consistency that can be easily pushed through the patient’s feeding tube. The volume of water added must be taken into account in any fluid plan.</td>
</tr>
<tr>
<td>4.</td>
<td>Measure the final volume (mL) of the blend and calculate the energy density of the final blend (Kcal/mL).</td>
</tr>
<tr>
<td>5.</td>
<td>From RER calculation and feeding plan, calculate the volume (mL) the patient should receive per day, and at each meal.</td>
</tr>
<tr>
<td>6.</td>
<td>After each meal the tube should be flushed with sufficient water to avoid clogging.</td>
</tr>
<tr>
<td>7.</td>
<td>The blended food should be stored in a refrigerator; for each new meal the correct volume should be stirred and warmed to body temperature before administering.</td>
</tr>
</tbody>
</table>
feeding early is hazardous. Overall effect on survival is unfortunately beyond these small trials; however, an important point about how early to intervene is that any patient receiving nutritional support should be cardiovascularly stable and hydration, electrolyte and acid-base disturbances should be addressed before nutritional intervention. Also, feeding after tube placement should really be withheld until at least the animal has recovered from anesthesia; feeding a recumbent animal risks aspiration. Patients with compromised gastrointestinal motility (e.g. anesthetized patients, patients on opioids analgesics, patients with ileus) are also at risk for complications and should be monitored closely.

### Monitoring and reassessment

Bodyweight should be monitored daily in all patients receiving nutritional support. However, the clinician should take into account fluid shifts when evaluating changes in body weight, and so body condition score assessment is also important. The use of the RER as the patient’s caloric requirement is merely a starting point; the number of calories provided may need to be increased to keep up with the patient’s changing needs, typically by 25% if well tolerated. In patients unable to tolerate the prescribed amounts, the clinician should consider reducing amounts of enteral feedings and supplementing the nutritional plan with either central or peripheral parenteral nutrition.

Possible difficulties with enteral nutrition include mechanical complications such as clogging of the tube (which should be flushed with water after each feed) or accidental removal. Metabolic problems include electrolyte disturbances, hyperglycemia, volume overload, and gastrointestinal signs (e.g. vomiting, diarrhea, cramping, bloating). In critically ill patients receiving enteral nutritional support, the clinician must also be vigilant for the development of aspiration pneumonia. Monitoring parameters for patients receiving enteral nutrition include bodyweight, serum electrolytes, tube patency, assessment of tube-exit site, gastrointestinal signs, and signs of volume overload or pulmonary aspiration.

Possible complications with parenteral nutrition include sepsis, mechanical problems with the catheter and lines, thrombophlebitis, and metabolic disturbances such as hyperglycemia, electrolyte shifts, hyperammonemia, and hypertriglyceridemia. Avoiding serious consequences from these complications requires early identification of problems and prompt action. Frequent monitoring of vital signs, catheter-exit sites, and routine biochemistry panels may alert the clinician to developing problems. Should persistent hyperglycemia during nutritional support become apparent, adjustments may be required (e.g. decreasing dextrose content in parenteral nutrition) or administration of regular insulin. This obviously necessitates more vigilant monitoring.

With continual reassessment, the clinician can determine when to transition a patient from assisted feeding to voluntary consumption of food. The discontinuation of nutritional support should only begin when the patient can consume approximately 75% of its RER without much coaxing.

### Impacting outcomes

Provision of nutrition is usually only considered a “supportive measure”, with other interventions (e.g. antimicrobials, corrective surgery, glucocorticoid therapy, fluid resuscitation) being more commonly associated in driving patient recovery. One assumption is that energy and substrates only serve to allow the body to repair itself. However, a growing number of veterinary studies have documented significant, clinically-relevant improvements in outcome measures (20,21). A pilot study to assess early enteral feeding in dogs with acute pancreatitis suggested a more rapid resolution of clinical signs compared to those fed parenterally, with both groups being fed an equivalent RER (20). In the recent study evaluating early enteral nutrition in dogs with septic peritonitis, investigators documented a shortened length of hospitalization (6). In terms of food
intake and impact on outcome, one study (7) noted that a voluntary food intake >66% (higher than RER) of maintenance energy needs was associated with a 93% hospital discharge rate whereas animals with a food intake <33% of needs had a 63% discharge rate. Although much work still needs to be done to evaluate the impact of nutritional support in critically ill patients, these studies strongly suggest a positive impact.

### Conclusion

While critically ill patients are often not regarded as having urgent need of nutritional support given their more pressing problems, the severity of their injuries, altered metabolic condition, and necessity of frequent fasting place these patients at high risk of becoming malnourished during hospitalization. Proper identification of these animals with careful planning and execution of a nutrition plan can be key factors for a successful recovery (Figure 3). As our understanding of various disease processes and their interactions with metabolic pathways improve, along with the refinement of nutritional support techniques, there is indeed great optimism that nutrition can have a significant positive impact on the recovery of critically ill patients.

### References