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Critical care nutrition of dogs

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Denise Elliott graduated from the University of Melbourne with a Bachelor in Veterinary Science with Honors in 1991. After completing an internship in Small Animal Medicine and Surgery at the University of Pennsylvania, Denise moved to the University of California-Davis where she completed a residency in Small Animal Medicine, a fellowship in Renal Medicine and Hemodialysis, and a residency in Small Animal Clinical Nutrition. Denise received board certification with the American College of Veterinary Internal Medicine in 1996 and with the American College of Veterinary Nutrition in 2001. The University of California-Davis awarded a PhD in Nutrition in 2001 for her work on Multifrequency Bioelectrical Impedance Analysis in Healthy Cats and Dogs. Denise is currently the Director of Scientific Communications for Royal Canin USA.

The beneficial effects derived from the nutritional support of diseased human patients and experimental animal models include enhanced immune function, wound repair, response to therapy, recovery time, and survival. Despite these benefits, the nutritional needs of hospitalized patients are often ignored due to the intense focus on life-threatening medical and surgical problems. The goal of nutritional support is to provide energy and nutrients in proportions that can be utilized by the patient with maximal efficiency.

Malnutrition is probably more common in veterinary patients than is recognized. Malnutrition is an unbalanced intake of protein and/or calories to support tissue metabolism and has the potential to undermine proper medical or surgical therapeutic management of a hospital case *(Remillard et al, 2001)*. Some dogs are likely to be deficient in either protein and/or calories due to a reduction in food intake.

A recent publication estimated the proportion of hospitalized canine patients in a negative energy balance *(Remillard et al, 2001)*. The study was conducted at four veterinary referral hospitals across the USA. Overall, daily feeding data and outcomes for 276 dogs over 821 days in the hospital were evaluated. In 73% of those days a negative energy balance was obtained (< 95% RER [resting energy requirement]).

This was attributed to three main factors:
- 22% due to poorly written orders
- 34% due to orders to withhold food
- 44% of the dogs refused to eat.

Overall, the study found that caloric intake had a significant, positive effect on patient outcome.

1 - Pathophysiology

Simple starvation implies that the patient is healthy, but is somehow deprived of food, while complicated starvation is reserved for patients where disease has induced a state of anorexia. The ability of the body to respond to starvation is often altered in disease. Therefore, the healthy dog's ability to cope with starvation should not be relied upon exclusively as a model for the sick and anorexic patient. Many disease states may result in an increased need for both energy and additional nutrients beyond what is required during simple starvation **(Table 1)**.

TABLE 1 - INFLUENCE OF STARVATION AND STRESS ON METABOLISM

	Starvation	Physiological stress
Activation of mediators	⇧	⇧⇧⇧
Protein synthesis	⇩	⇩⇩
Catabolism	⇩	⇧⇧⇧
Gluconeogenesis	⇧	⇧⇧⇧
Energy expenditure	⇩	⇧⇧
Malnutrition level	⇧	⇧⇧⇧

There are marked elevations in catecholamines, glucocorticoids and glucagon in patients that are physiologically stressed. Although the exact increase in nutrient requirements in differing states of complicated starvation is not known, it is significant justification for nutritional support.

No evidence suggests that there are specific and consistent risk factors for needing nutritional support. Disease severity has been the only common factor among patients in need of nutritional support.

Independent of breed predisposition for diseases that require nutritional support for patient management, no breed is more likely to need nutritional support than another.

2 - Indications for nutritional support

Some clinicians find it helpful to have metrics to use to determine when to intervene with nutritional support. Ideally, a specific and sensitive biomarker that is easily measured would exist as such an indicator. Unfortunately, despite attempts at identification, no one reliable indicator exists *(De Bruijne, 1979; Fascetti et al, 1997)*. However, there are recommendations in the literature regarding patient criteria that can serve as indicators to when nutritional support should be instituted *(Remillard et al, 2001)*.

► First criterion: the length of anorexia prior to presentation or anticipated duration of anorexia

Canine patients that have been anorexic for three to five days are already in a state of starvation and, based on human respiratory quotients (RQs), are relying mainly on muscle and adipose tissue as energy substrates *(Owen et al, 1979)*. There are no protein stores in the body, and, therefore, any catabolism results in the loss of functional proteins. A state of protein catabolism is contraindicated in any state of disease and minimizing or eliminating this catabolism is vital to the successful management of critically ill patients.

If anorexia lasts or is expected to last at least three to five days, it should elicit a nutritional response (enteral or parenteral feeding).

Not all patients have a clear starting point regarding anorexia. The client may not have recognized diminished food intake depending on the patient's home environment and the feeding strategy employed.
- Food intake for patients residing in a multi-dog household fed ad libitum is notoriously difficult to assess.
- Clients may, in hindsight, be reluctant to admit the length of anorexia or may exaggerate food intake.

In order to address this difficulty, the authors recommend that the practitioner make an effort to quantify the volume of food that the animal is consuming. Using this information, the approximate caloric intake of the patient can be calculated and compared to the animal's energy requirement **(see section 5B for energy requirement calculations)**.

It is even more difficult to anticipate the length of expected anorexia. Disease progression is inherently unpredictable; however, many diseases do behave relatively predictably. In cases where there is a high likelihood that the patient will not eat voluntarily, plans should be made to provide nutritional support. Anticipating the potential need for nutritional intervention when patients undergo anesthesia for further diagnostics or treatment is strongly recommended. In this case, concurrently placing a feeding tube during the procedure is a critical management strategy. This approach drastically increases the odds that patients in need of nutritional support will receive it.

► Other criteria: body condition score, body weight change and albumin status

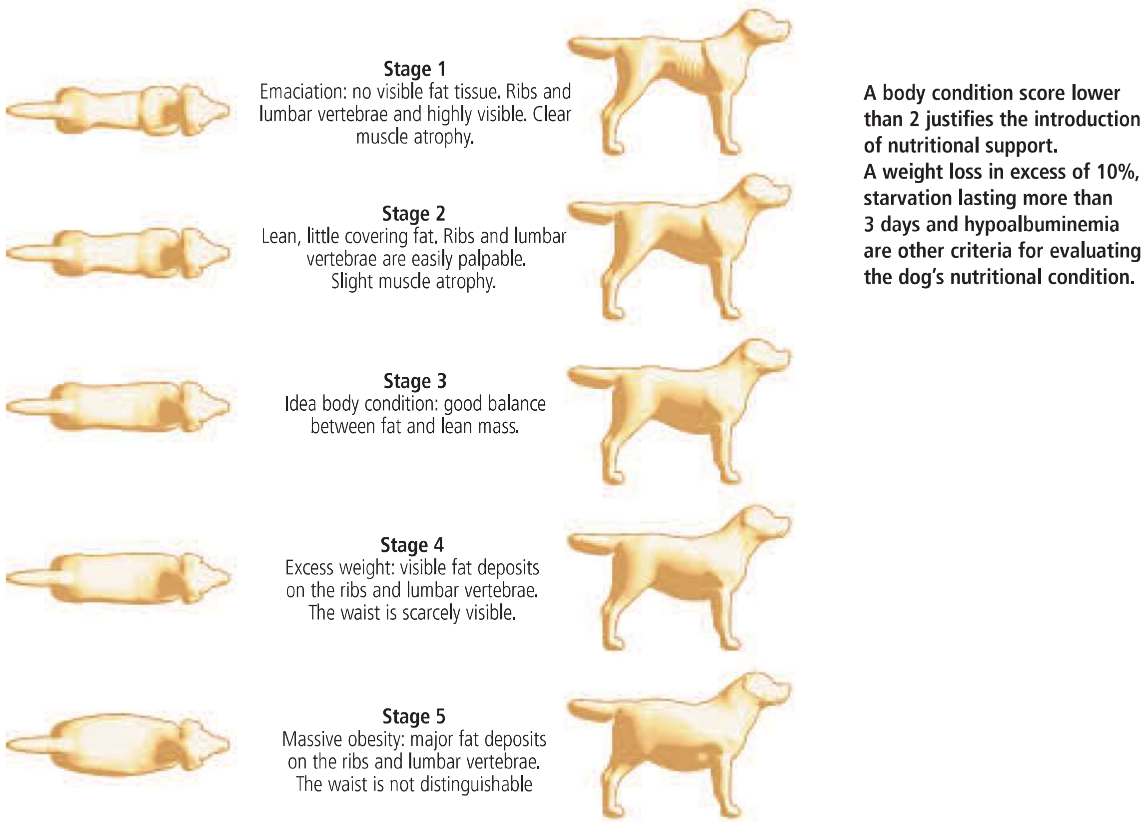
There are three parameters that need to be monitored in order to ensure that nutritional support is adequate.
- Patients with a body condition score of less than 3 on a 9-point scale *(Laflamme et al, 1994)* or 2 on a 5-point scale *(Edney & Smith, 1986)* should be considered to be in poor nutritional status, and nutritional support should be considered immediately **(Figure 1)**.
- A body weight reduction of greater than five or ten percent that is not due to dehydration also signals the need for immediate nutritional support.
- Hypoalbuminemia due to decreased production is a clear indicator that intervention should occur.

3 - Supplementary tests

► Diet history

Collecting an accurate and complete diet history should be done for every patient and can prove to be very helpful in determining the length and degree of anorexia. Clients should be carefully

FIGURE 1 - 5 POINT BODY CONDITION SCORING SYSTEM



questioned not only about the brand and type of food offered, but also about the amount and the feeding frequency. The diet history should include enough detail to allow for the total daily caloric intake to be determined and compared to the calculated caloric requirement. The determination of food intake is often complicated by the fact that many clients have moved away from the patients' typical diets to novel foods in an attempt to entice their pets to eat. The new foods are frequently higher in moisture and/or fat content. The loss of an easy comparison makes interpreting unintentional weight loss difficult. There is a natural tendency to assume that the patient's food consumption has been adequate, since that would imply a better prognosis to the client and that the veterinarian would not need to intercede with nutritional support. However, this assumption must be proven quantitatively.

Fortunately, the advent of the internet has made previously difficult to find energy density data more accessible to anyone with computer access. Many pet food manufacturers' websites provide kilocalories per volume or kilogram often not found on their product labels. In addition, product guides are readily available from many manufacturers. Energy density data for human foods can be easily obtained from the USDA Nutrient Database for Standard Reference, which is available at *www.nal.usda.gov*. The lead author's (SJD) website (*www.balanceit.com*) is also designed to provide information for petfood as well as for human food. With these tools, accurate and complete diet histories can be evaluated in all patients and used to determine the degree and length of patient anorexia.

► Body weight

Determination of a patient's body weight, adjusted for hydration status, is an important clinical measurement. However, for the critically ill patient in need of nutritional support, its value is diminished unless recent body weight data is available. Comparisons should only be made based on readings from the same scale, since scale-to-scale variation can be misleading.

Every animal should be weighed, and weight readings should be recorded daily during hospitalization. Intervention that only occurs when the patient has lost weight while hospitalized is a poor management strategy. Ideally, all hospitalized patients will remain relatively weight stable or, if indicated, gain weight during their stay. Weight gain should be interpreted cautiously as most patients will gain weight upon rehydration. Thus, every patient should be weighed daily to ensure that nutritional intervention is appropriate. The routine occurrence of weight loss in hospitalized patients should be a clear sign to the clinician that nutritional intervention is not adequate or has not been instituted soon enough.

Beauceron on the scale *- A body weight that was recorded years or even months earlier cannot be used to determine the rate of unintentional weight loss.*

► Body composition

Clinical assessment of body composition is limited to a validated system of using visual and tactile cues for assessing adiposity *(Laflamme et al, 1994)*. Although the body condition scoring system has limitations, such as in its inability to quantify lean body mass, it requires minimal training and no special patient preparation or equipment.

More precise experimental methods of determining body composition such as dual energy X-ray absorptiometry (DEXA), bioelectrical impedance, and stable isotope dilution, are technically and economically demanding, limiting their clinical use.

Thus, the use of a body condition score (BCS) is the most practical method of quantifying a patient's body composition **(Figure 1 and see Chapter 1)**. It is also an excellent tool to convey a "picture" of the animal to colleagues in the same practice or to referring veterinarians. Although subtle changes over several days cannot be detected by even the most experienced clinician, the use of a BCS does provide an insight into the patient's overall nutritional status that cannot be achieved by measuring body weight alone. Therefore, a BCS should be used as a measure of the "chronic" condition, and daily body weight changes should be used as indicators of the more "acute" condition.

Body weight and BCS are usually not dynamic enough for daily evaluations and adjustments, but rather they are a better indicator of an animal's long-term response to nutritional support.

► Albumin status

Approximately 50% of all daily protein synthesis is committed to the production of albumin. Inadequate intake of dietary protein can impair that production. However, given that albumin's half-life in the dog is approximately eight days, reflective changes in albumin status can take days to occur *(Kaneko et al, 1997)*. An example of the discrepancy between albumin status and caloric intake is provided in a paper by De Bruijne *(1979)*. In this study, no changes in blood albumin concentrations were detected in healthy dogs undergoing simple starvation for 21 days. In another study, admission serum albumin concentration of 105 hospitalized dogs was shown to have a statistically significant predictive value regarding clinical outcome *(Michel, 1993)*. Thus, reductions in albumin should be seen as evidence that production is severely decreased, or may not be keeping up with demand, or that losses are excessive. Consequently, normoalbuminemia should not be used as justification for foregoing nutritional intervention.

► Other Biomarkers

Currently, no single clinical pathology or biochemical marker exists that helps to determine the nutritional status of dogs. Leukopenia, creatine kinase in cats and proteins such as C-reactive protein, prealbumin, transferrin and retinol binding protein in humans have all been investigated as measures of nutritional status. However, all of these biomarkers are affected by multiple other factors that render their interpretation difficult *(Phang & Aeberhardt, 1996; Fascetti et al, 1997)*. At this time, the clinician's best tools for nutritionally assessing their patients are:

- complete medical and dietary histories
- physical examinations
- body weights
- current and historical BCSs
- and routine blood work.

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Weighing a West Highland White Terrier puppy
Early enteral nutrition helps combat weight loss and minimizes the effects of catabolism in diseases such as parvoviral gastroenteritis.

4 - Determination of the best approach regarding nutritional support: decision trees

Nutrients can be administered two ways: enterally or parenterally. It is the clinician's responsibility to determine the best approach regarding nutritional support for each patient **(Figure 2)**.

Parenteral nutrition should be used only when enteral feeding is not possible. Parenteral nutrition is complicated, more expensive and concerns regarding infection exist.

5 - Enteral nutrition

Enteral nutrition should be the first choice for nutritional management unless the patient's condition can not support enteral feedings. The mantra "If the gut works, use it" was derived because enteral feeding is considered more physiologically sound than intravenous feeding. Enteral feeding maintains the health of the gastrointestinal tract, and prevents bacterial translocation. A recent randomized controlled clinical trial investigated the effect of early enteral nutrition in dogs with parvo-viral enteritis, compared to nil per os *(Mohr et al, 2003)*.

Enteral nutrition was associated with a shorter time to recovery, increased body weight gain, and improved gut barrier function. This study suggests that early enteral feeding is associated with more rapid clinical improvement. Enteral feeding can be achieved via nasoesophageal, esophagostomy, gastrostomy or jejunostomy devices.

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Most critically ill patients will tolerate nasoesophageal tube placement, but some individuals may require sedation.

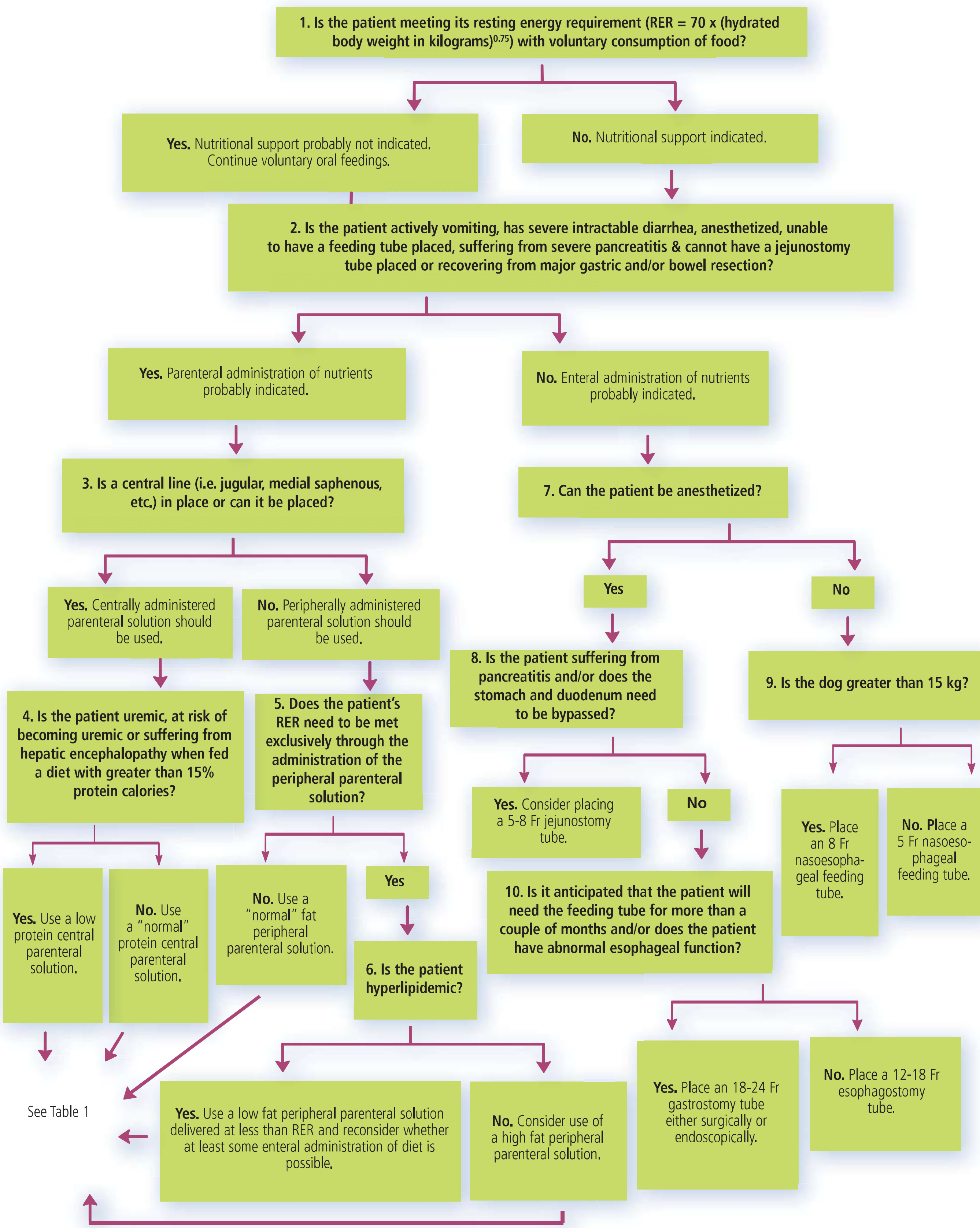
► Different types of tubes for enteral nutrition

The appetite of the hospitalized patient typically waxes and wanes. Hence the meal is offered orally, and if not consumed, is blended and administered via a tube.

> Nasoesophageal tubes

This type of tube is an excellent option for short-term feeding (<7 days) of hospitalized patients. Nasoesophageal tubes do not require specialized equipment and are not expensive. Generally tubes between 3-8F are selected. For a dog, the optimal length of the nasoesophageal tube is equal to the distance from the tip of the nose to the seventh rib.

FIGURE 2 - ALGORITHM TO ASSIST THE SELECTION OF THE TYPE OF NUTRITIONAL SUPPORT TO IMPLEMENT



Contraindications include patients that have had severe facial trauma involving the nares, protracted vomiting and/or regurgitation, semiconsciousness, or those patients that have laryngeal, pharyngeal, or esophageal physical or functional abnormalities.

However, the small diameter of the tube can be inconvenient and mandates only liquid feedings. Nasoesophageal tubes may also increase the risk of aspiration pneumonia if the tube is either inadvertently placed in the trachea, or the pet regurgitates the tube and it is inhaled into the trachea. To minimize this complication, the placement of the nasoesophageal tube should always be ascertained prior to feeding.

There are three ways of placing an esophagostomy tube:

- via a percutaneous needle technique
- via surgical cut-down
- by utilizing the Eld percutaneous feeding tube applicator.

> Esophagostomy tubes

Esophagostomy tubes are indicated for patients requiring medium term nutritional support. Esophagostomy tubes are generally well tolerated and can easily be placed under a light anesthetic with minimal equipment. The only major associated complication is the potential for infection at the entry site and meticulous care of the surgical wound is essential to maintain the tube. Indications include patients with mandibular, maxillary, nasal and nasopharyngeal disease or an inability to prehend or masticate.

The patient is lightly anesthetized, placed in right lateral recumbency, and an aseptic preparation of the left cervical region is performed. A 5-12 Fr red rubber, plastic or silicone feeding tube can be placed.

The tip of the esophagostomy tube should be placed in the mid-esophagus. The exterior portion of the tube is secured to the neck via butterfly or Chinese finger trap suture.

Feeding through the tube can commence once the patient has recovered from anesthesia. The food must be presented in the form of liquid slurry: it may be a dry or canned food mixed with water or a ready to use solution. The wound will heal via granulation tissue within two weeks of tube removal.

FIGURE 3 - DIFFERENT TYPES OF GASTROSTOMY TUBES

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Gastrostomy tubes are available in several sizes and designs and are constructed of latex or silicone. The most common initial placement design is a latex Pezzar-type mushroom catheter. Silicone tubes typically survive 6-12 months and are less irritating at the stoma site.

> Gastrostomy tubes

Gastrostomy tubes are available in several sizes; 18-20 Fr are appropriate for small dogs, and 24 Fr are adequate for larger dogs. Tubes are constructed of latex or silicone. Various designs are available **(Figure 3)**. An array of feeding adapters can be attached to the feeding tube; a Y-port device is preferred as it has two ports:
- a catheter port for administration of food when the tube has been in place for at least 24 hours
- a Luer tip syringe port used for oral medication.

More recently low-profile gastrostomy devices (LPGD's) have been developed and are available in North America for both initial and replacement procedures. These devices are positioned flush with the body wall **(Figure 4)**. LPGD's are constructed of silicone and appear to cause less stoma site inflammation. A feeding adapter is attached to the end of the device during the feeding procedure.

FIGURE 4 - ILLUSTRATION OF A LOW PROFILE GASTROSTOMY TUBE AFTER PLACEMENT

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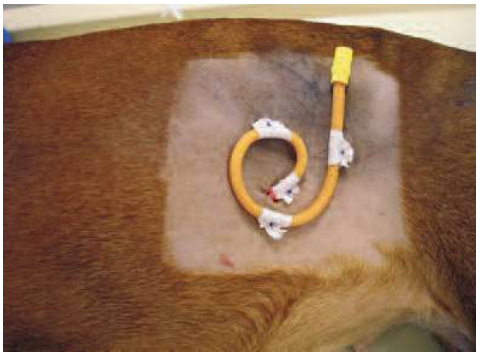
Client and patient acceptance is much higher than with traditional tubes as the patient appears "normal" without a long tube attached to the body or the need for a stockinette cover. In addition, the mushroom tip has an anti-flux valve design to prevent reflux of gastric contents.
LPGD's are expensive but have been documented to last at least 12 months.

FIGURE 5 - ILLUSTRATION OF A DOG WITH A TRADITIONAL GASTROSTOMY TUBE AFTER PLACEMENT



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Latex tubes are less expensive but generally require replacement within 8-12 weeks due to tube wear and tear.

Silicone tubes typically survive 6-12 months and are less irritating at the stoma site **(Figure 5)**.

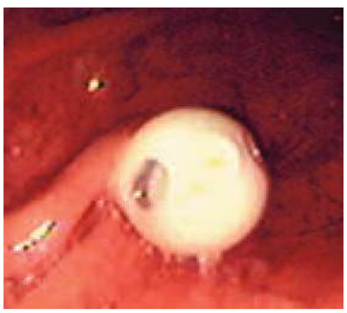
> Jejunostomy tubes

Jejunostomy tube feeding is justified only when the stomach or the duodenum must be by-passed. The tube is typically placed via laparotomy and enteropexy. The food used must be liquid and elemental as tubes are typically 5-8 Fr in diameter and inserted directly into the jejunum.

► Enteral tube feeding: practical aspects

Water is introduced through the feeding tube 12-18 hours following initial placement (except for feeding via the esophagus when no delay is necessary), and feeding is scheduled to begin within 24-36 hrs. Generally 1/2 to 1/3 of the daily caloric intake (typically RER) is administered on the first day.

$*RER = 70 \times (\text{body weight in kg})^{0.75}$ = kilocalories/day



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An endoscope should be used to verify that the gastrostomy tube is in the correct position.

If no complications occur, the amount fed is gradually increased to reach total caloric requirements by the third or fourth day, or the seventh day in case of prolonged starvation.

The total volume of food is divided into 4-6 equal sized meals which should not exceed the gastric capacity of the patient (initially 5 mL/kg to up to 15 mL/kg per feeding). The food should be warmed to room temperature and administered slowly, over 5-15 mins **(Figure 6)**. Upon completion, the tube should be flushed with 5-10 mL of tepid water.

Research shows no beneficial effect from continuous intragastric feeding over intermittent enteral feeding with regard to weight gain and nitrogen balance in healthy dogs *(Chandler et al, 1996)*. However, in animals that are volume intolerant, continuous administration of nutrients is better tolerated.

FIGURE 6 - ENTERAL FEEDING

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The diet is blended with the least amount of water required to achieve syringability. If the food is administered as a slurry, the tip of the syringe must be sufficiently wide to prevent obstruction.

Frequent small meals are generally better tolerated than larger less frequent meals. If the owner feels able to continue frequent feedings when the dog is discharged from the hospital then such a regimen should be continued. However, if frequency will need to be reduced, it is important that the dog is adapted to the larger less frequent meals that the owner will employ at home prior to discharge. With time and adaptation to the feeding procedure, the meal frequency may be reduced to a convenient BID to TID daily schedule.

Prior to every meal, the gastric residuals should be aspirated with a syringe. If more than 50% of the prior feeding is present, the contents should be returned to the stomach and the feeding skipped until the next scheduled time. Frequent aspiration of the previous meal may suggest delayed gastric emptying and warrant medical management (e.g. metoclopramide 20-30 minutes prior to feeding).

Most oral medications should be administered prior to feeding, with the exception of phosphate binders that must be mixed directly with the food.

The position of the tube on the body wall should be examined daily for migration and the stoma site inspected for pain, redness, odor and discharge **(Figure 7)**. The site should be cleaned daily with an antiseptic solution and antimicrobial ointment applied. Food residue should not be left near the stoma.

► Nutritional support

> Water

Water is one of the four basic macronutrients, and, in a state of deficiency, will cause the most immediate detrimental effects. Therefore, nutritional support in its most minimal form is provided to most hospitalized patients in the form of ad libitum water and/or parenterally administered fluids. Unfortunately, there is a tendency to only administer the minimum and provide no further support. Fluid therapy should be viewed as a component of nutritional support and not as complete nutritional support.

> Energy density of the diet

Most veterinary clinical nutritionists believe that the energy requirement of most hospitalized patients is close to a patient's resting energy requirement (RER), calculated using the above equation *(Remillard et al, 2001)*.

FIGURE 7 - MIGRATION OF THE GASTROSTOMY TUBE IN THE SUBCUTANEOUS TISSUE

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This situation is a surgical emergency as it may result in septic peritonitis.

Although this equation does not always meet the patient's precise needs, it serves as a starting point that should minimize the likelihood of overfeeding or underfeeding the patient. It is the authors' experience that, for most dogs, using RER results in weight stability and maintenance of the patient's BCS during several weeks of hospitalization.

To keep the volume of any single bolus at a minimum, the energy density of the diet must be maximized. To achieve this, the volume and type of liquid used to lower the viscosity of a canned food must be carefully selected. The importance of finding a balance between slurry energy density and viscosity cannot be overemphasized. Even small increases in the kilocalories per unit volume can often have a large impact on the frequency and the volume of enteral feedings. This, in turn, can significantly affect the success of the feeding program and the ability to meet the animal's energy requirements.

Oil provides the maximum amount of energy, but also the greatest dilutional effect on nutrients. Thus, essential nutrients can be significantly decreased inadvertently. Using water does not change the ratio of nutrients to kilocalories, but does decrease the amount of kilocalories per unit volume. Alternatively corn or maple syrup can be used in dogs to increase the energy density of a slurry while still decreasing the diet's viscosity. In most cases, water can effectively be used to create slurries that can then be fed through a 12 Fr or larger feeding tube. As a general guide, increasing the canned diet to a moisture level of 80% typically creates a slurry once blenderized that is both relatively energy dense (diet dependent) and easily administered **(Figure 8)**.

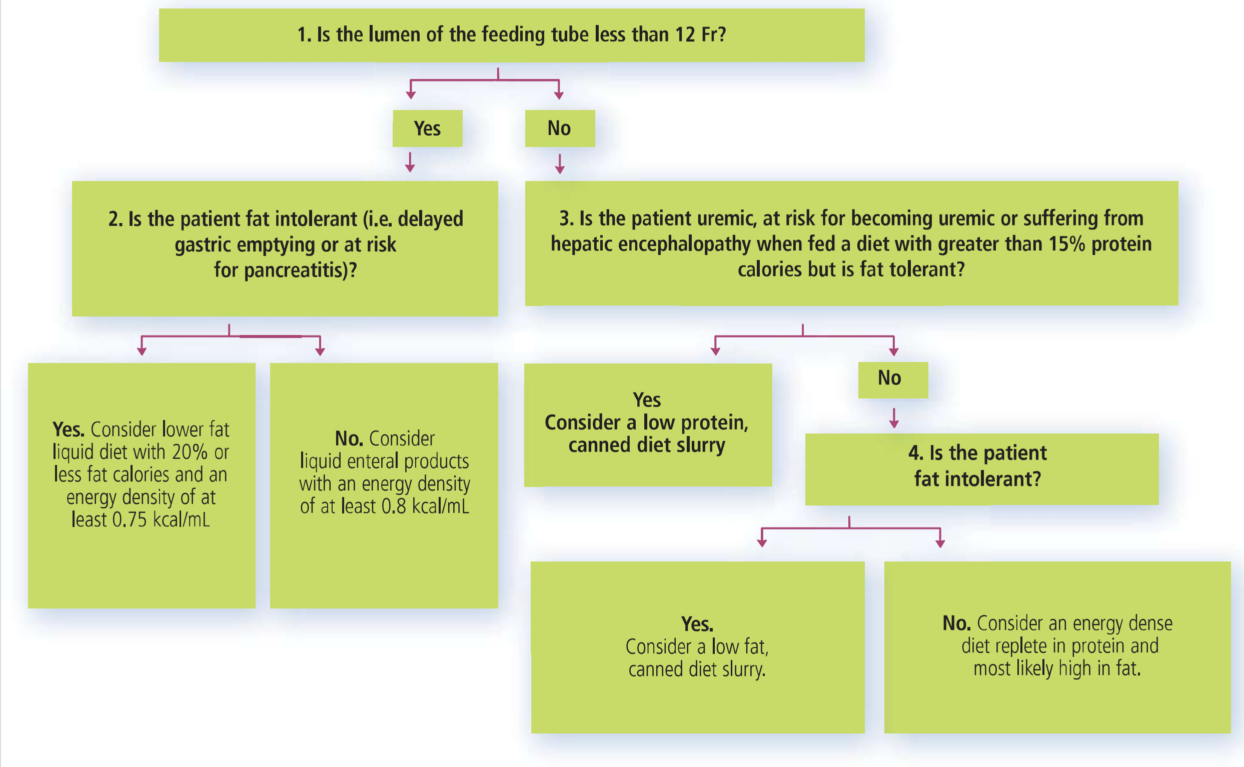
> Balance of energy sources

The basic macronutrients that provide energy are protein, fat and carbohydrate. When the patient's resting energy requirement is not met with the administration of a single energy-providing macronutrient, there is debate as to how the macronutrient is utilized. Some believe that all macronutrients are used solely for energy until the patient's energy requirements are met. Others advocate that some substrates may have a limited, protein-sparing effect even when the patient's caloric requirements are not being achieved.

- ***Fats***

High fat diets, as a rule, are usually well accepted and tolerated. Fat provides at least twice as many calories per unit of volume, thereby enabling an increased caloric consumption in patients with

FIGURE 8 - ALGORITHM TO ASSIST THE SELECTION OF THE ENTERAL TUBE FEEDING DIET



limited food intake. Although fat can increase the palatability and the initial acceptance of a diet, it is the authors' experience that sudden increases in dietary fat appear to be one of the most consistent and least recognized causes of gastrointestinal distress, especially pancreatitis.

Many highly digestible commercial foods are not fat-restricted and often provide up to 30% of the calories from fat. The use of these diets should be limited to patients in which there is no concern of fat intolerance.

When initially refeeding a hospitalized patient, such foods as cottage cheese or skinless chicken combined with rice are often recommended. These foods are palatable, highly digestible and are excellent alternatives to high-fat commercial foods.

• *Amino acids*

Enterally administered amino acids such as glutamine have been suggested to have a protein-sparing effect. There is one study that supports the potential benefit of enterally administered glutamine based on whole-body leucine kinetics *(Humbert et al, 2002)*.

Unfortunately, there is no clinical evidence that a patient will tolerate an enterally administered amino acid solution in amounts to meet their energy needs, when they will not tolerate a complete diet. However, a constant rate infusion of an enteral product below the patient's RER, with the concurrent administration of the remaining caloric requirement parenterally may be of value in reducing the occurrence of villous atrophy and bacterial translocation *(Qin et al, 2002; Kotani et al, 1999)*.

► Complications linked to enteral feeding

For critically ill dogs, the majority of the monitoring is focused on avoiding complications associated with nutritional support.

> Surgical complications

Splenic laceration, gastric hemorrhage, pneumoperitoneum, displacement into the peritoneal cavity and peritonitis have been reported as infrequent placement complications.

Patient tolerance of the feeding tube should be closely observed. This can manifest as sneezing, cellulitus at the stoma, gagging, and/or vomiting, depending upon the type of tube. The major associated complication is the potential for infection at the entry site.

Meticulous care of the surgical wound is essential to maintain the tube. Abnormalities at the stoma site including discharge, pain, swelling, erythema, abscess formation and ulceration which can be minimized by strict attention to cleaning and prohibiting the patient from licking the site. Warm packs containing antiseptic solution placed on the stoma site will minimize problems or hasten recovery.

Inappropriate patient removal of the tube is undoubtedly the most problematic complication. In one review approximately 20% of dogs removed their gastrostomy tubes which emphasizes the importance of restraining the gastrostomy tube in a stockinette and utilizing e-collars **(Figure 9)** *(Elliott et al, 2000)*.

Patient removal of the gastrostomy tube is an emergency. In most situations a new tube can be placed through the existing stoma site using a guide catheter. Appropriate replacement should be verified radiographically following injection of an iodinated contrast agent. If the tube has been in place for less than seven days, or there is evidence of peritonitis or radiographic contrast agent leakage, an exploratory laparotomy is required to correct the situation. The use of LPGD's may reduce the incidence of inadvertent gastrostomy tube removal.

> Obstruction of the tube

Periodically tubes will become blocked with food. Techniques to facilitate removal of the obstruction include massaging the outside of the tube while simultaneously flushing and aspirating with water; instilling carbonated drinks (e.g. cola soda), meat tenderizers or pancreatic enzyme solutions for 15 to 20 minutes; or gently using a polyurethane catheter to dislodge the obstruction. The final resort is tube removal and replacement.

> Aspiration Pneumonia

The perception of enteral feeding increasing the risk of aspiration pneumonia in the critically ill patient is most likely justified if the enteral feeding increases the risk of the patient vomiting, or aspirating or if the patient is laterally recumbent, sedated or anesthetized. Incorrectly positioned nasoesophageal tubes will cause aspiration pneumonia when the food is inadvertently placed into the trachea, and not the esophagus.

Gastric contents following enteral feedings serve as an excellent reservoir of pneumonia-genic compounds given their acidity and high microbial load. However, it should be noted that a human produces up to 63 mL per hour of bacteria-laden saliva *(McClave & Snider, 2002)*. Thus, it is most likely inappropriate to assume that all aspirated material comes from the stomach. The role of enteral feeding in the development of aspiration pneumonia is controversial in the human arena *(McClave & Snider, 2002)*. However due to the more horizontal, rather than vertical posture of dogs, it appears likely to play a significant role in the canine patient.

FIGURE 9 - FIXATION OF THE TUBE

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A traditional gastrostomy tube must be protected from the risk of displacement by the dog. This can be achieved by securing the gastrostomy tube to the body wall, placing a stockinette over the abdomen, and using an Elizabethan collar.

Intolerance to enteral feeding is usually related to an excessive meal volume which exceeds gastric capacity. The frequency with which clients can administer feedings is generally limited. Patient discomfort, the risk of diarrhea and vomiting can be minimized by:
- reducing the total volume (increase the meal frequency and/or the meal energy density)
- slowing down the rate of administration
- serving the food at ambient temperature
- reducing the food's osmolarity
- simultaneously managing fluid, electrolyte and acid base disturbances.

In order to prevent Refeeding Syndrome, the following three steps should be taken:

(1) Slow re-introduction of food to animals that have been unfed for extended periods (greater than 5 days);
(2) Provide adequate supplementation of potassium, phosphorus and potentially magnesium;
and
(3) Closely monitor electrolytes during the first 24 hours of refeeding.

> Overfeeding

Volume intolerance is a frequent complication of enteral feeding in humans *(Davies et al, 2002)* It can lead to simple nausea or to vomiting.

The total number of daily kilocalories to be delivered has a large impact on individual bolus volume. Overestimating the energy requirement of a patient increases the risk of volume intolerance. In human medicine, initial energy requirement recommendations for enteral feeding that are too aggressive often result in the patient receiving fewer kilocalories per day due to skipped feedings based on residuals and/or volume intolerance *(McClave & Snider, 2002)*.

There is debate regarding the predictive ability of gastric residuals (leftover stomach contents measured by aspiration before the next feeding) in avoiding aspiration pneumonia in humans *(McClave & Snider, 2002)*. The volume of each feeding may not be solely responsible for residual volume as gastric emptying rate also plays a role. However, intuitively, it seems like a good indicator of feeding volume tolerance.

Finally, diarrhea can occur with any form of enteral feeding, especially when undigested nutrients or non-elemental diets are fed too rapidly into the jejunum (due to osmotic effects), or when the food is too cold.

> Refeeding syndrome

This syndrome may occur after enteral feeding, as studies on cats and humans have shown *(Solomon & Kirby, 1990; Justin & Hohenhaus, 1995)*.

In a state of starvation, the body maintains extracellular concentrations of many electrolytes at the expense of intracellular concentrations. This shift can result in inward rectification when glucose and, subsequently, insulin are reintroduced to the patient with refeeding. This inward rush results in acute decreases in vital serum electrolyte concentrations that can potentially be life threatening. For example, serum potassium concentration is maintained as intracellular potassium is depleted. When blood glucose rises in response to feeding, the body releases insulin that pumps glucose and potassium intracellularly. The result is a rapid and profound hypokalemia **(Figure 10)**. Hypomagnesemia and hypophosphatemia have also been reported *(Justin & Hohenhaus, 1995; Macintire, 1997)*. Hypophosphatemia has been associated with hemolysis and could lead to additional cardiac and neurological complications *(Justin & Hohenhaus, 1995)*.

6 - Parenteral feeding

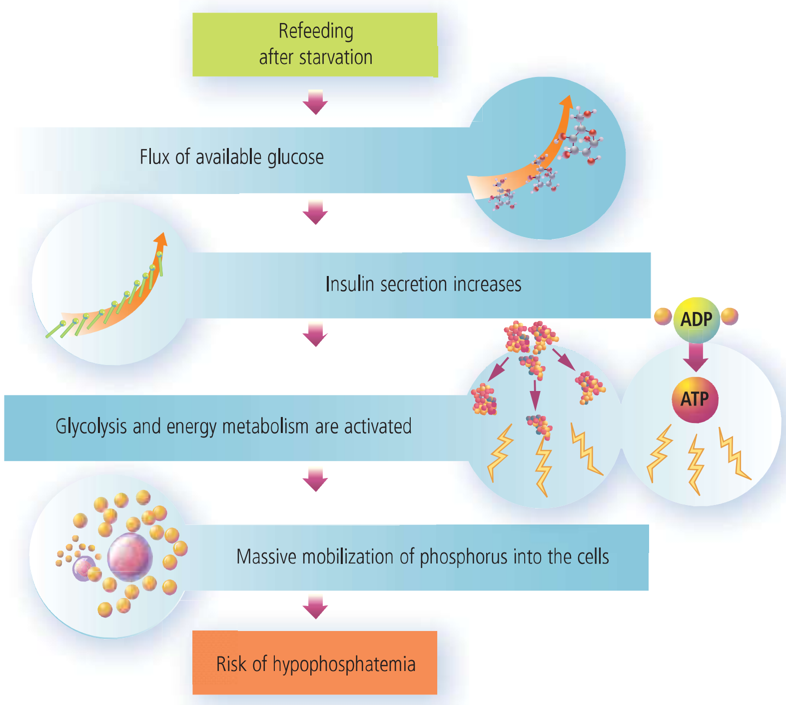
Parenteral feeding is expensive and technically demanding. It is reserved for cases in which the digestive tract must be rested for medical or surgical reasons or in recumbent patients.

► Practical aspects

> Preparation

All the elements are mixed carefully in a sterile bag, in the following order: glucose then amino acids then lipids. The introduction of lipids at the end avoids the risk of emulsion destabilization. The bag is refrigerated and the contents used in less than 48 hours by connection to the intravenous infusion system.

FIGURE 10 - PHYSIOLOGICAL MECHANISMS THAT MAY RESULT IN HYPOPHOSPHATEMIA ASSOCIATED WITH THE REFEEDING SYNDROME



> Catheter placement sites

The dog is anesthetized or simply tranquilized if it is already weak. The injection site is surgically prepared **(Figure 11)**.

Due to their high glucose and amino acid content the solutions for parenteral feeding are often very hypertonic. Their administration must therefore be accomplished with a central catheter placed in the cranial (jugular approach – **Figure 12**) or caudal vena cava (saphenous approach). The major blood flow of these veins permits rapid dilution of the mixture.

***Figure 11** - Placement of a central jugular catheter.*

***Figure 12** - The high flow of the cranial vena cava permits rapid dilution of the parenteral solution.*

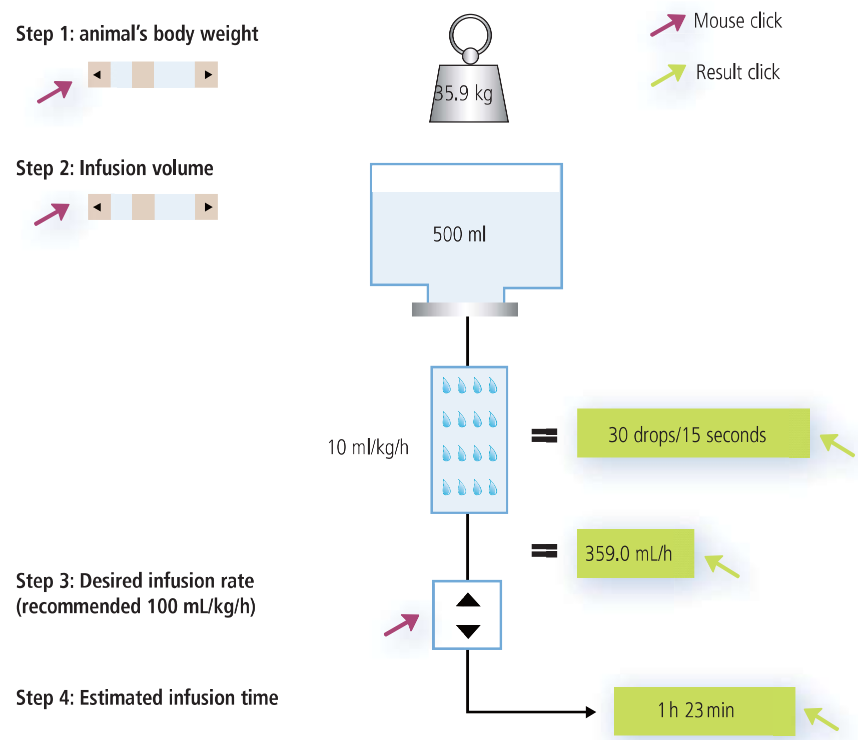
> Rate of administration

The rate of administration of parenteral solutions is limited by three main factors - fluid volume, osmolarity and the creation of metabolic disturbances. Software is available that can adjust the infusion flow based on the characteristics of the animal.

> Fluid volume

Fluid volume is rarely a major concern except in patients that are fluid overloaded or oliguric/anuric, for example, patients with congestive heart failure, acute renal disease or terminal chronic renal disease. When fluid volume is a concern, an effort should be made to increase the energy density of the solution by increasing the lipid emulsion content when possible.

ADJUSTING THE INFUSION (FOR CRYSTALLOID SOLUTIONS ONLY)



Software can be used to regulate the infusion rate in terms of the number of drops/15 seconds, and control the infusion time in accordance with the animal's body weight, the total infusion volume and the desired rate per hour (mL/kg/h).

> Electrolyte composition

The electrolyte composition of the parenteral solution can also be adjusted along with the amount of free water to allow for its use as a maintenance fluid and decrease overall administered fluid volume. Use of a solution with a high osmolarity can increase the risk of thrombophlebitis *(Roongpisuthipong et al, 1994)*. For example, a solution with an osmolarity of 650 mOsmol/L delivered through a peripheral catheter at maintenance fluid rates is well-tolerated *(Chan et al, 2002; Chandler et al, 2000a)*. However, the same solution delivered at twice the maintenance rate will not be as well-tolerated based on human studies *(Kuwahara et al, 1998)*. On the other hand, a solution with an osmolarity of 1300 mOsmol/L may theoretically be tolerated if delivered at one half of the normal maintenance rate.

> Metabolic complications

Common metabolic complications associated with parenteral nutrition include:

- hyperglycemia
- hyperlipidemia
- Refeeding Syndrome.

Hyperglycemia can be associated with the rapid administration of dextrose containing solutions that exceed the ability of the pancreas to respond to the hyperglycemia and to secrete appropriate

TABLE 2 - PROTOCOL TO REGULATE BLOOD GLUCOSE (BG) CONCENTRATIONS

Protocol Blood Glucose
Initially start the infusion at 1/4 to 1/3 of goal rate and wean on per guidelines below increasing the rate in 1/3 to 1/4 of goal rate increments. The same recommendations in reverse apply to discontinuing the infusion. Recommend checking the administration rate every 4hr until 100% of goal rate is achieved.

Blood Glucose (mg/dL)	Action
< 70 mg/dL or 4 mmol/L	Possible problem with the measurement, administration, formula and/or patient. Check to ensure that the correct solution is being administered and that the patient does not have an underlying reason to become hypoglycemic. Consider increasing the administration rate and/or concentration of dextrose in the formula.
< 250 mg/dL or 14 mmol/L	Increase the infusion rate towards 100% of the goal rate if weaning on. Continue at the present rate if already at 100% of goal rate.
250-300 mg/dL or 14-17 mmol/L	Hold the present infusion rate during the weaning on period. Continue the infusion at the present rate if already at 100% of goal rate. Decrease the administration rate if the glucose level continues to be elevated over three to four measurements obtained at 4hr intervals or if the urine glucose is over 1+ on a urine dipstick test.
> 300 mg/dL or 17 mmol/L	Decrease the infusion rate. If the goal rate cannot be reached without >300 mg/dL glucose levels consider: 1. Accepting the highest infusion rate that the animal will tolerate; 2. Adding regular insulin to the nutrient solution (1 unit/10 g dextrose) 3. Decreasing the dextrose content of the solution.

concentrations of insulin. Avoidance of hyperglycemia is frequently achieved by reducing the rate of infusion and/or the administration of exogenous insulin .

Similarly a state of **hyperlipidemia** may develop when the patient's ability to metabolize the delivered fat is exceeded.

The Refeeding Syndrome refers mainly to electrolyte shifts associated with glucose transport into cells following the reintroduction of food after prolonged anorexia. To minimize most of these complications careful monitoring and a weaning protocol should be utilized. Should electrolyte abnormalities occur with refeeding, the authors recommend reducing and/or gradually discontinuing the rate of solution administration, while simultaneously correcting any electrolyte abnormalities. Once the electrolyte abnormalities have resolved, then administration can be resumed or increased to meet energy requirements.

► Covering nutritional requirements

(Table 3)

TABLE 3 - CANINE PARENTERAL NUTRITION WORKSHEET

1 - DETERMINE IF THE SOLUTION IS TO BE ADMINISTERED PERIPHERALLY OR CENTRALLY
If peripheral, use a 5% dextrose solution. If central (i.e. for a dog with a jugular catheter), use a 50% dextrose solution.

2 - SELECT THE DESIRED CALORIC DISTRIBUTION ON A PERCENT OF METABOLIZABLE ENERGY (%ME)*			
	Protein (%ME)	**Fat (%ME)**	**Carbohydrate (%ME)**
Low	8-10	20	0-18
Normal	16-18	30-58	20-50
High	20-22	60-80	Contraindicated

* *Only one macronutrient can be low or high at one time. Thus, the other two macronutrients must be in the normal range if the third is low or high. The exception to this rule is when creating a high fat solution.*

Selected % ME protein	…%
Selected % ME fat	…%
Selected % ME carbohydrate (CHO)	…%
TOTAL **(MUST = 100%)**	…%

3 - CALCULATE DAILY CALORIC REQUIREMENT OF THE HOSPITALIZED PATIENT	
If to be delivered peripherally (not using a high fat solution)	1/2 RER = 35 x (… body weight in kg)$^{0.75}$ = … kcal/day
If to be delivered peripherally (using a high fat solution) or centrally	RER = 70 x (… body weight in kg)$^{0.75}$ = … kcal/day

4 - CALCULATE THE DAILY VOLUME OF EACH MACRONUTRIENT		
… % of ME protein	x … kcal/day = … ÷ … kcal/mL for amino acid solution	= … mL
… % of ME fat	x … kcal/day = … ÷ … kcal/mL for lipid emulsion solution	= … mL
… % of ME CHO	x … kcal/day = … ÷ … kcal/mL for dextrose solution	= … mL
	TOTAL ml	= … mL

5 - Check the osmolarity

… mL of amino acid solution	x … mOsmol/mL of amino acid solution	= … mOsmol
… mL of lipid emulsion solution	x … mOsmol/mL of lipid emulsion solution	= … mOsmol
… mL of dextrose solution	x … mOsmol/mL of dextrose solution	= … mOsmol
	TOTAL mOsmol	= … mOsmol

(… Total mOsmol ÷ … Total mL) x 1000 = … mOsmol/L)
if mOsmol/L > 750 mOsmol/L & the solution is to be delivered peripherally, increase the %ME fat
if mOsmol/L > 1400 mOsmol/L & the solution is to be delivered centrally, increase the %ME fat

6 - Calculate energy density of the solution

… mL of amino acid solution	x … kcal/mL of amino acid solution	= … kcal
… mL of lipid emulsion solution	x … kcal/mL of lipid emulsion solution	= … kcal
… mL of dextrose solution	x … kcal/mL of dextrose solution	= … kcal
	TOTAL kcal	= … kcal

(… Total kcal ÷ … Total mL) x 1000 = … kcal/L)

if the kcal/mL < 0.4 kcal/mL and the solution is to be delivered peripherally (not using a high fat solution), increase the %ME fat and/or check the calculations
if the kcal/mL < 0.7 kcal/mL and the solution is to be delivered peripherally (using a high fat solution), increase the % ME fat and/or the % ME protein and/or check the calculations
if the kcal/mL < 0.9 kcal/mL & the solution is to be delivered centrally, increase the %ME fat and/or check calculations.

7 - Calculate the amount of potassium and phosphorus to add to the solution

Desired potassium concentration … mEq/L
x (… Total mL ÷ 1000)
= … mEq K to add

Desired phosphorus concentration … mEq/L
x (… Total mL ÷ 1000)
= … mEq P to add

Phosphorous supplementation should be considered cautiously in patients with renal insufficiency.
Potassium supplementation should be reflective of the patient's potassium status.

8 - Calculate the amount of Vitamin B Complex to add to the solution

a. There is a wide variation in the concentrations of B vitamins in commercially available products. Provide enough B Vitamins to meet the following requirements:

Thiamine	0.29 mg/1000 kcal solution
Riboflavin	0.63 mg/1000 kcal solution
Pantothenic acid	2.9 mg/1000 kcal solution
Niacin	3.3 mg/1000 kcal solution
Pyridoxine	0.29 mg/1000 kcal solution
Vitamin B12	0.006 mg/1000 kcal solution

Supplementation with fat soluble vitamins or trace minerals does not appear to be essential. Unless a specific deficiency is evident, the likelihood of developing a clinically significant deficiency in two to three weeks is highly unlikely.

b. Recommended concentrations and characteristics of macronutrients

	mOsmol/mL	kcal/mL	g protein/mL
8.5% amino acid solution without electrolytes	0.78-0,88	0.34	0.085
20% lipid emulsion solution	0.27	2.0	
5% dextrose solution	0.25	0.17	
50% dextrose solution	2.52	1.7	

NOTE: There is debate regarding the amount of amino acids available for protein synthesis if the patient's resting energy requirement (RER) is not met. Therefore, some clinicians will provide the patient with their RER exclusively from fat and carbohydrate and calculate the protein requirement separately. The authors have included the energy contribution of protein in their parenteral solution calculations to provide consistency with accepted methods of evaluating oral/enteral diets. To determine the grams of protein per 100 kcal calories the following calculation can be performed:

…mL of amino acid solution
x … g of protein per mL amino acid solution
= … g protein

(… g protein x … Total kcal)
x 100
= … g protein/100 kcal

c. Standard canine recommendations on a g protein/100 kcal basis

Low	< 4.0 g/100 kcal
Normal	4.0-8.0 g/100 kcal
High	> 8.0 g/100 kcal

Case study: A 20-kg dog whose resting energy requirement equals $70 \times (20)^{0.75}$ = 660 kcal/day.

A liter of 5% dextrose solution provides 200 kcal. 3.3 L will therefore be necessary to cover the dogs daily RER, which is much greater than the volume needed to guarantee the dog's hydration status and would most likely result in thrombophlebitis.

MONITORING PROTOCOLS FOR PARENTERAL FEEDING MUST INCLUDE THE FOLLOWING DAILY EVALUATIONS:

- body weight
- temperature
- pulse
- breathing and heart rate
- thoracic auscultation
- catheter position and integrity
- blood glucose concentration and/or urine glucose every 4 hours during the weaning on period
- hematocrit and evaluation of serum for lipemia or jaundice.
- potassium and phosphate in the 12-24 hours following initial administration
- BUN and albumin concentration in the 24 hours following initial administration, and thereafter every 2-3 days

It is also recommended to measure ionized magnesium concentrations (where possible) in the 24 hours following initial administration, and perform a complete blood count and biochemical panel every 2-3 days. Depending on the case, thoracic radiographs and serum triglyceride analyses may be of value.

> Dextrose

It is common for clinicians to "spike" crystalloids used for fluid therapy with dextrose in an attempt to provide some nutritional support. Since chronic infusion of greater than 5% is not performed due to the concern of thrombophlebitis from a hyperosmolar solution, patients only receive approximately a third of their RER when this solution is administered at maintenance fluid rates. There is debate regarding the protein-sparing effect that 5% dextrose provides, but limited research has shown that it is not enough to prevent a negative nitrogen balance *(Chandler et al, 2000b)*.

> Amino acids

A study did find that infusion of a 5% amino acid solution resulted in a mean positive nitrogen balance in three, healthy dogs *(Chandler et al, 2000b)*. However, the success of this therapeutic approach in a larger population of dogs in a catabolic state needs to be determined before this form of nutritional support can be endorsed.

> Fats

The ideal solution for parenteral administration would be an energy dense solution with a low osmolarity. Some view lipid emulsions as such an ideal solution. For example, a 20% lipid emulsion can provide 2 kcal/mL with an osmolarity of 268 mOsmol/L. Although the kcal to osmolarity ratio of this solution is ideal, concern exists regarding excessive fat administration. Intravascular fat accumulation has been reported in premature infants with liver dysfunction receiving lipid emulsions *(Levene et al, 1980; Puntis & Rushton, 1991; Toce & Keenan, 1995)*.

In the limited number of cases where this approach has been used, patients have tolerated solutions providing up to 80% of RER from fat. The safety and efficacy of administering 100% of a patient's RER from fat requires further investigation and cannot be recommended at this time.

7 - Complications linked to enteral or parenteral feeding

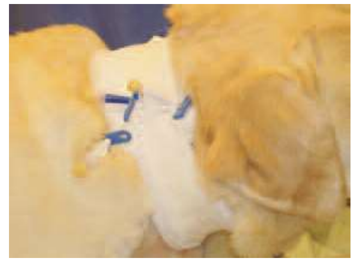
► Thrombophlebitis

Hyperosmolar solutions increase the risk of thrombophlebitis. For peripheral vessels, it is recommended that solutions not exceed 600 to 750 mOsmol/L *(Chan et al, 2002; Chandler et al, 2000a)*. The rate at which milliosmoles (mOsmol) are administered clinically appears to be as crucial as the osmolarity of the solution. Therefore, a 650 mOsmol solution should not be administered at twice the maintenance rate for the purpose of increasing the amount of calories delivered to the patient per unit of time. This limitation results in the need to use parenteral solutions containing high lipid emulsion concentrations with a high energy to milliosmole ratio, or to provide only a portion of the patient's energy requirement. One author reports that using polyurethane catheters in previously unused vessels for the administration of peripheral parenteral solutions when administrating peripheral parenteral nutrition (PPN) is well tolerated *(Chan et al, 2002)*.

► Septicemia

Parenteral nutrition solutions represent an ideal culture environment for bacteria. To minimize the infection risk these solutions should be prepared and administered in completely aseptic conditions.

Once it is in place the catheter and the tube must be protected from any risk of contamination by using a dedicated catheter. Medication must not be administered through the dedicated catheter nor should blood be drawn from the dedicated catheter.



Once it is in position, the catheter and the intravenous tubing must be protected from any risk of contamination.

► Hyperglycemia

There is a growing body of evidence in the human literature that blood glucose clamping with exogenous insulin of ICU patients may decrease mortality rates. This is due to a reduction in multiple-organ failure secondary to sepsis *(van den Berghe, 2002)*.

The effect appears to be due to the maintenance of euglycemia rather than the beneficial effect of insulin itself, since in humans increased insulin administration is positively associated with death *(Finney et al, 2003)*. Hyperglycemia has long been known to decrease immune function due to adverse effects on polymorphonuclear leukocyte phagocytosis as well as impaired chemotaxis, phagocytosis and intracellular killing as seen in diabetic subjects *(Watters, 2001)*. This may, in part explain the lower incidence of sepsis in patients receiving 50% of their RER from PPN in a review by Chan *(2002)* compared to the frequency reported in two retrospective TPN studies by Reuter et al *(1998)* and Lippert et al *(1993)*. Although patient selection probably plays a key role in the likelihood of developing septicemia, it is possible that the lower incidence of hyperglycemia associated with the use of PPN was also important.

► Villous atrophy and bacterial translocation

The enterocytes rely heavily on nutrients derived from the gut lumen as energy sources *(Ziegler & Young, 1997)*. Thus, available energy for enterocytes is diminished with the use of parenteral nutrition. This reduction results in decreased enterocyte health and villous atrophy, and in turn increased intestinal permeability.

The loss of intestinal integrity can increase the risk of gut flora entering the bloodstream; referred to as bacterial translocation *(Steinberg, 2003)*. There is debate as to when and if this breakdown occurs, but in humans it usually occurs after a prolonged period of parenteral nutritional support and may not be as significant as rodent models would indicate *(Alpers, 2002)*.

There is also controversy regarding the best method of preventing villous atrophy and bacterial translocation. While some human and animal studies suggest that infusing glutamine as an energy substrate to prevent villous atrophy and bacterial translocation has some benefit, other studies have not proven this to be an effective intervention *(Buchman, 1999; Marks et al, 1999)*. In addition, possible contraindications exist, such as liver disease – especially hepatic encephalopathy, and possibly renal disease.

► Adynamic ileus

Adynamic ileus is a common sequela of anorexia, especially in patients supported with parenteral nutritional support. Enteral feeding may decrease this risk as hormonal and neurologic signals are restored by the presence of nutrients in the gut lumen. Adynamic ileus does not always occur, and in many patients normal peristaltic reflexes continue with high pressures being generated during fasted states *(Heddle et al, 1993)*. This point has implications for patients that have undergone intestinal surgery.

The convention of resting the bowel to prevent leakage through enterostomy sites may be flawed. There is evidence that early enteral feeding following major abdominal surgery may be preferable to parenteral support *(Braga et al, 1998 & 2002)*.

Conclusion

- Nutritional support is indicated in canine patients with prolonged anorexia, recent body weight loss unrelated to hydration status, poor body condition and hypoalbuminemia not due to correctable losses.

- Nutritional support can enhance immune function, wound repair, response to therapy, recovery time, and survival.

- Selection of the route and diet for nutritional support should be based on patient tolerance and prevention of adverse side effects.

- Administration of single macronutrients may not be adequate to meet the patient's energy and nutrient requirements and may provide only a limited protein-sparing effect.

- The administration rate of nutritional support should provide the patient's resting energy requirement without increasing the likelihood of volume intolerance or metabolic complications like hyperglycemia, hyperlipidemia and the refeeding syndrome.

- Monitoring of patients on nutritional support should be aimed at preventing adverse complications and to ensure successful management.

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Diet is an integral part of treatment during the period of hospitalization. Malnutrition hampers the dog's recovery from critical illness.

Key Points
to remember:

Critical care nutrition of dogs

• Ideally, a dog should retain a stable body weight during hospitalization (or gain weight where appropriate). Daily weighing is imperative. **Nutritional support will be needed for a patient with inadequate food intake (real or foreseen) of 3 days or more.**

• **Enteral feeding is by far the best method of nutritional support**: it avoids atrophy of the intestinal villi and facilitates faster recovery. When enteral feeding is impossible, the length of time that food is withheld from the intestine must be minimized.

• **The energy requirement of a hospitalized dog can be compared to that of a resting dog.** Its value is estimated at no less than 70 kcal/kg $(BW)^{0.75}$. It must be understood however that individual variations can increase this requirement by 30%.

• The diet's energy concentration must be maximized, in order to limit meal volumes. The higher the fat content the greater the energy density. Administration of 30-50% of the calories as fat should be the aim. The ideal solution is a diet that has a combination of high energy density and is easy to suspend in water.

• The protein content should be sufficient to maintain a positive nitrogen balance. **Provision of 30-50% of total calories from protein helps combat loss of lean body mass.**

• Be aware that a solution with a high glucose content may promote hyperinsulinemia and hyperglycemia. **Do not exceed 10-25% of total calories as glucose.**

• The fluid-electrolytic balance must be monitored very closely in critically ill dogs: blood potassium, phosphorus and magnesium concentrations are especially important. Rehydration solutions help correct some electrolyte deficiencies.

Pros and cons of different types of enteral or parenteral foods			
Type of food	**Pros**	**Cons**	**Indication**
Hand feeding	- Simple - Not stressful for the dog	- Time consuming - Applicable only in some cases	Very short-term feeding
Appetite stimulants	Few available	Hepatotoxicity possible	Short-term feeding (2-3 days)
Nasoesophageal feeding	- Easy to place tube - Non-invasive - Minimal tranquillization - Few complications	- Tube not always tolerated - Elizabethan collar mandatory - Liquid diet	Short-term feeding (1-2 weeks)
Esophageal feeding	- Easy and fast tube placement - Elizabethan collar not mandatory - No nasal irritation - Does not prevent the dog from eating	- Special equipment required - General anesthetic mandatory	Several weeks of supported feeding
Gastrostomy feeding	- Easy to maintain tube in position - Few complications	- Risk of infection of insertion site	Several months of supported feeding
Jejunostomy feeding	Bypass the pancreas	- General anesthetic mandatory - Delicate tube placement - Intensive care required - Elemental nutritional solutions	Pathology of stomach, duodenum or pancreas
Parenteral feeding	Permits nutritional support during digestive surgery or serious digestive complaint	- Cost - Constant surveillance - Major risks: metabolic complaints, thrombophlebitis, septicemia, atrophy of the intestinal villi, Adynamic ileus	Any situation in which the digestive tract needs rest

Focus on:

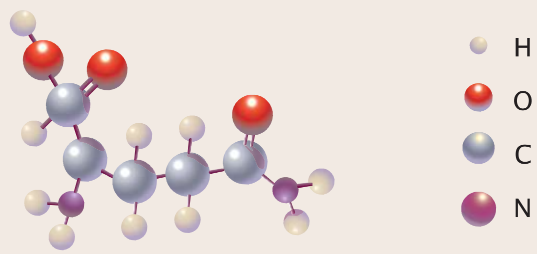
GLUTAMINE

The increased rate of gluconeogenesis accelerates glutamine catabolism in an animal under stress. In the presence of this greater requirement, muscle synthesis of glutamine is often insufficient and the glutamine blood concentration falls. Although glutamine is not an essential amino acid, it may become conditionally essential in some situations.

Glutamine has multiples functions: it participates in maintaining the acid-base balance, it is a precursor of puric and pyrimidic bases, it regulates some hepatic syntheses and it participates in detoxification processes.

Glutamine is a particularly important substrate for rapidly dividing cells such as the cells of the digestive tract and the immune system.

CHEMICAL FORMULA OF GLUTAMINE



Glutamine is used by immunoglobulin A-producing cells of the intestinal mucosa. A low dietary intake combined with a high requirement in critically ill animals may affect the integrity of the intestinal barrier, leading to a greater risk of bacterial translocation and systemic infection.

While glutamine (250-500 mg/kg/day) is recommended for the prevention of atrophy of the intestinal villi, it is not systematically incorporated in parenteral nutrition solutions as preparations for intravenous use are difficult to obtain *(Elliott, 2004)*.

Reference

Elliott D - Parenteral nutrition. Scientific Proceedings WSAVA - FECAVA 2004; HVMS World Congress, Rhodes (Greece).