NUTRITIONAL MANAGEMENT OF THE HOSPITALIZED AND CRITICALLY ILL PATIENT

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“All deaths are hateful to miserable mortals, but the most pitiable death of all is to starve”
Homer, Odyssey XII:341

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, veterinarians frequently ignore or delay the nutritional needs of sick animals. In addition, the nutritional needs of critical patients are largely forgotten due to the intense focus on life-threatening medical and surgical problems. The goal of nutritional support is to provide a formula of fuels and nutrients in proportions that can be utilized by the patient with maximal efficiency.

Metabolism of illness:

A change in metabolism occurs following injury, stress, and certain diseases and are characterized by the need for increased calories and altered fuel sources. Patients suffering from extensive burns and severe head trauma have the greatest increase in caloric requirements. The marked elevation of catecholamines, glucocorticoids, and glucagon, in addition to peripheral insulin resistance, cause a direct increase in the metabolic rate leading to a rapid mobilization of tissue energy stores in patients not receiving adequate nutritional support. Body weight may increase initially because increased secretion of aldosterone and ADH increase sodium retention and extracellular fluid volume. If the injury persists or is accompanied by malnutrition, there may be immunosuppression, increased bacterial translocation with increased risk of sepsis, and delayed wound healing and prolonged hospitalization.

Indicators for Nutritional Support:

In general, dogs and cats that have been anorectic for > 5 days or that have lost >10% body weight should be considered for nutritional support. In addition, patients that are hypoalbuminemic or that have conditions requiring increased nutrient demands such as extensive trauma or burns are viable candidates for nutritional support. Patients with conditions causing increased nutrient losses (excessive gastrointestinal or renal protein loss) also warrant nutritional support.

The following steps should be followed when evaluating nutritional support of the sick animal:
1. **Assess nutritional status:**

Nutritional support of sick animals is facilitated by obtaining a comprehensive dietary history, performing a physical examination, and determining appropriate laboratory parameters.

Although body weight is routinely determined in sick animals, it is important to understand its limitations:

- One cannot equate the appearance of the animal with its state of nourishment because body weight does not differentiate between fat, lean tissue, and extra-cellular water.
- Objective measurements are superior to “eyeball” measurements.
- There is no single “gold standard” test of a patient’s nutritional status.
- Inexpensive determinations of nutritional status include weight loss, serum albumin concentration, and total lymphocyte count.

2. **Estimate proportions of fuel sources:**

The sick animal will be using primarily fat for energy, but also using protein for energy and anabolism. Carbohydrates may be poorly utilized because of peripheral insulin resistance. High carbohydrate feeding may lead to hyperglycemia, glucosuria, hyperosmolarity, hepatic dysfunction, and respiratory insufficiency. The goals for dietary intake in dogs and cats will approximate:

- **Protein**: 30 to 50% of the metabolizable energy of the diet
- **Fat**: 30 to 50% of the metabolizable energy of the diet
- **CHO**: 10 to 25% of the metabolizable energy of the diet

3. **Calculate approximate caloric needs:**

Nutritional support provides substrates for gluconeogenesis and protein synthesis and provides the energy needed to meet the additional demands of host defense, wound repair, and cell division and growth. An estimate of the animal’s nutrient requirements is needed to determine the minimum amount of food necessary to sustain critical physiologic processes.

Accurate, direct measurements of energy expenditure in sick dogs and cats are not available. Despite the paucity of data on energy requirements of sick animals, opinion exists that the requirements of critically ill animals are less than normal maintenance amounts, but slightly greater than RER. The RER is the patient’s energy requirement at rest in a thermoneutral environment and in a post-absorptive state. The veterinary literature is rife with reports documenting various values or factors for altering initial calculations to determine the patient’s final caloric requirement. This practice should be discouraged because the ability to discriminate between a patient requiring 1.2 and 1.5 times the RER is virtually impossible. One should rather view the RER as an estimate and recognize that the caloric requirements in sick animals may well increase above the RER or need to be decreased slightly below the calculated RER. Close observation of the patients body weight changes, ongoing losses (diarrhea, vomiting, exudative wounds) and physical examination findings (decreased subcutaneous fat stores, muscle wasting, presence of edema or ascites) will help determine whether to increase or decrease the patient’s caloric intake above or below the calculated RER.

A linear formula can be applied to determine the RER of patients weighing at least 2 kg. Alternatively, one can utilize an allometric formula that can be applied to dogs and cats weighing < 2 kg.

**Linear formula:** \[ \text{RER (kcal/day)} = (30 \times \text{BW}_{\text{kg}}) + 70 \quad (\text{Body weight} > 2 \text{ kg}) \]

**Allometric formula:** \[ \text{RER (kcal/day)} = 70 \left(\text{BW}_{\text{kg}}\right)^{0.75} \quad (\text{Body weight} < 2 \text{ kg or} > 45 \text{ kg}) \]
4. **Calculate amount of diet to feed:**

   This requires knowledge of the energy density of the diet selected. The food dosage can be determined by dividing the animal’s energy requirement (RER) by the energy density of the diet.

5. **Select route of diet administration:**

   The preferred route of nutrient administration is by oral or enteral feeding. Enteral feeding is the safest, simplest, least expensive, and most physiologic route, and should be used whenever possible. In animals that are totally or partially anorexic, enteral feeding can be accomplished by one of several techniques: appetite stimulation, force feeding, and tube feeding.

**Appetite stimulants:**

Mainly utilized in cats with partial anorexia. Commonly used drugs include diazepam, cyproheptadine, and mirtazapine. Diazepam should be avoided in cats with liver disease because of the potential for inducing hepatic necrosis.

**Force feeding:**

This technique is of limited benefit and is stressful for cats and dogs in which it is performed. In addition, force-feeding can precipitate a conditioned food aversion and should therefore be abandoned in favor of tube-feeding techniques if voluntary food intake does not fulfill the patient’s caloric requirements.

**Enteral feeding access devices**

Most feeding tubes today are made of polyurethane or silicone. These materials have tended to replace the older polyvinylchloride feeding tubes that tend to stiffen when exposed to digestive juices and are more irritating to patients, necessitating frequent tube replacement. Silicone is softer and more flexible than other tube materials with a greater tendency to stretch and collapse. Polyurethane is stronger than silicone, allowing for a tube of this material to have thinner walls and thus a larger internal diameter, despite the same French size. The flexibility and decreased internal diameter of silicone tubes may lead to clogging or kinking of the tube. Both polyurethane and silicone do not rapidly disintegrate or become brittle in situ, providing a longer “wear”. The French (F) unit measures the outer lumen diameter of a tube (each French unit is equal to 0.33 mm). Tubes that are too flexible may be chilled before placement to increase stiffness.

a) **Nasoesophageal** - simple and efficient choice for the short-term (less than 10 days) nutritional support of most anorectic hospitalized patients that have a normal nasal cavity, pharynx, esophagus, and stomach. Nasoesophageal tube feeding is contraindicated in animals that are vomiting, comatose, or lack a gag reflex. Polyvinylchloride (Infant Feeding Tube, Argyle Division of Sherwood Medical, St. Louis, MO) or red rubber tubes (Sovereign Feeding Tube, Monoject Division of Sherwood Medical, St. Louis, MO) are the least expensive tubes for dogs and cats, although the polyvinylchloride tubes may harden within 2 weeks of insertion and cause irritation or ulceration of the pharynx or esophagus. Tubes made of polyurethane (Travasorb Feeding Tube, Travenol Laboratories, Deerfield, IL), or silicone (Cook Nasal Feeding Tube, Cook Veterinary Products, Bloomington, IN) are more expensive; however, they are less irritating and more resistant to gastric acid, allowing prolonged usage. A 8 French × 42 inch tube (preferably with a stylet) is suitable for dogs weighing more than 15 kg. A 5 or 6 French × 36 inch tube is recommended for dogs weighing less than 15 kg and for cats.
The length of tube to be inserted into the distal esophagus is determined by measuring the distance from the tip of the nose to the seventh intercostal space in dogs and from the tip of the nose to the ninth rib in cats. This will help verify the correct placement of the tube in the distal esophagus rather than the stomach. Nasogastric tubes traverse the distal esophageal high-pressure zone increasing the risk of reflux esophagitis and stricture formation. Chemical restraint is rarely required for passage of a nasoesophageal tube; however, topical installation of a local anesthetic is necessary to desensitize the nasal cavity. Desensitization of the nasal cavity with four or five drops of the topical ophthalmic anesthetic 0.5% proparacaine hydrochloride (Ophthalmic, Allergan) or 4 to 5 drops of 2% lidocaine hydrochloride for dogs is recommended. The tip of the tube should be lubricated with a water soluble lubricant or 5% lidocaine ointment to facilitate passage. The tube is passed by maintaining the animal’s head in the normal angle of articulation and gently directing the tip of the tube in a ventromedial direction. The tube should move with minimal resistance through the ventral meatus and nasopharynx and into the esophagus. In dogs, the presence of a small ventral ridge at the proximal end of the nasal passage necessitates directing the tip of the tube dorsally initially to allow passage over the ventral ridge and into the nasal vestibule. Nasoesophageal intubation is more difficult to perform in dogs because of their long, narrow nasal passages and extensive turbinate structures. In the dog, the tube is directed in a ventromedial direction while pushing the external nares dorsally. This maneuver opens the ventral meatus and guides the tube into the oropharynx. Advancement of the tube into the pharynx usually elicits a swallowing reflex.

If the tube is unable to be passed with minimal resistance into the oropharynx, it should be withdrawn and redirected because it could be positioned in the middle meatus with its tip encountering the ethmoid turbinate. Once the tube has been passed to the level of the attached “butterfly” tape, it should be secured as close to the nostril as possible, with either suture material or superglue. A second tape tab should be secured to the skin on the dorsal midline between the eyes. An Elizabethan collar is usually required for dogs to prevent the inadvertent removal of the tube, however, most cats do not require such a device. Removal of the tube is facilitated by clipping the hair that is attached to the glue.

The tube position is checked by injecting 5 to 10 ml of air while auscultating the cranial abdomen for borborygmus, or by infusing 3 to 5 ml of sterile saline or water through the tube and observing for a cough response. Confirmation of correct tube placement can also be obtained by obtaining a lateral survey thoracic radiograph and observing the position of the radiopaque tube in the esophagus. The most common complications associated with the use of nasoesophageal tubes include epistaxis, dacrocystitis, rhinitis, tracheal intubation and secondary pneumonia, and vomiting. Pneumothorax secondary to nasojejunal intubation and esophagitis with stricture formation are less common serious complications. The risk of tracheal intubation can be minimized by verifying the position of the feeding tube before securing it and before each feeding.

A major disadvantage of nasoesophageal feeding tubes is their small diameter, necessitating the use of liquid enteral formulas. Commercially available canned pet foods that are diluted with water will invariably clog the feeding tube. The caloric density of most human and veterinary liquid enteral formulas varies from 1.0 to 1.5 kcal/ml. Diets are fed full strength on continuous (pump infusion) or bolus feeding schedules.

b) Pharyngostomy - Although relatively easy to place, the technique has become virtually obsolete with the advent of percutaneous gastrostomy and esophagostomy tube placement. Pharyngostomy requires general anesthesia and meticulous attention when being placed to avoid interference of epiglottic movement and partial obstruction of the larynx.
c) **Esophagostomy** - The technique for surgical placement of a midcervical tube esophagostomy in dogs and cats was refined in an effort to avoid the complications associated with aspiration or laryngeal obstruction that may occur with pharyngostomy and nasoesophageal tube placement. The tubes are easily inserted, and insertion only requires light general anesthesia or heavy sedation. The only major complication that has been associated with esophagostomy tube placement is wound infection at the ostomy site where the tube exits the skin. Daily meticulous care of the ostomy site has been effective in preventing infection.

Three techniques for tube esophagostomy placement have been described. The patient should be placed in right lateral recumbency, and the left cervical region aseptically prepared for tube placement. The first method is a percutaneous (needle) technique which incorporates the use of an intravenous jugular vein catheter inside a 14-gauge needle. The author’s preferred method uses a curved Carmalt forceps or similar right-angled forceps. Advance the right-angle forceps into the midcervical esophagus from the oral cavity. Use the angle of the jaw and the point of the shoulder for landmarks to help ensure that the tip of the forceps can be palpated externally in the midcervical region. Push the curved tips of the forceps laterally at the midcervical esophagus, so they can be palpated below the skin. Use a number 11 scalpel blade to make a stab incision through the skin only, exposing the subcutaneous tissue and muscle layers of the esophagus. Be careful to avoid the jugular and maxillofacial veins when selecting the stoma site. Exteriorize the tip of the forceps from the esophageal lumen through the skin incision. Guide the advancing forceps through the esophageal muscle layers and carefully dissect the esophageal mucosa off the tip of the forceps with a scalpel blade. Use the tip of the forceps to grasp the distal end of the feeding tube and draw the tube out of the oral cavity. Secure the distal end of the feeding tube using the forceps to ensure that the tube remains exteriorized while the proximal end of the tube is pulled out of the animal’s mouth. Retroflex the proximal tip of the feeding tube and advance it in an aboral direction across the pharynx and down the esophagus, while slowly retracting on the external end of the tube 2 to 4 cm. A wire guide can be used to facilitate pushing the proximal tip of the feeding tube into the esophagus. The exteriorized portion of the tube will be observed to rotate in a cranial direction as the tube moves down the esophagus, indicating correct placement of the tube in the esophagus. Retention sutures (Chinese finger-trap suture) using 2-0 polypropylene are used to secure the distal end of the tube to the skin. An additional method of securing the tube involves passing a heavy suture on a taper needle through the skin next to the tube and into the periosteum of the wing of the atlas. Antibiotic ointment and gauze dressing are placed at the incision site, and the tube and entrance site is loosely bandaged with conforming gauze wrap. The correct placement of the tube in the mid to distal esophagus should be confirmed radiographically. Despite the potential for esophageal scarring and stricture formation, esophageal stricture or a persistent esophagocutaneous fistula has not developed.

d) **Gastrostomy** - Requires general anesthesia, with placement of the tube via percutaneous placement or during laparotomy. This procedure enables one to place relatively large diameter catheters into the patients stomach, with most dogs tolerating 24 Fr tubes and cats tolerating 20 Fr tubes.

e) **Surgical (Open) Jejunostomy Technique** - The needle catheter jejunostomy is a quick, easy method developed by Delany. A purse-string suture (3-0 polyglactin 910) is placed through the antimesenteric border of the proximal jejunum through which a 12-gauge hypodermic needle is directed aborally and tunneled subserosally for several centimeters before entering the bowel lumen. A 5 French polyvinylchloride tube (Infant Feeding Tube, Argyle Division of Sherwood Medical, St. Louis, MO) is introduced into the bowel lumen through the hypodermic needle and is advanced for 20 to 30 cm aborally. The needle is removed and the purse-string suture is tightened and tied. The free end of the catheter is exteriorized by advancing it through a second sterile hypodermic needle that is passed from
the prepared skin surface on the right ventrolateral abdominal wall into the peritoneal cavity. The enterostomy site is fixed to the abdominal wall with interrupted or continuous sutures passing through the intestinal submucosa and abdominal fascia.

6. **Select diet if feeding via enteral route:**

The type of formula to feed the patient will depend on the selected route of feeding, the functional status of the gastrointestinal tract, and the patient’s nutrient requirements. Other factors, such as cost, availability, and ease of use may also be important. Patients that are fed via nasoesophageal or jejunostomy feeding tubes are limited to receive liquid enteral formulas. Most commercially available liquid diets have a caloric density of approximately 1 kcal per ml. The protein content of an enteral nutrition product is probably the most important component. When selecting a liquid formula for feeding, one should pay particular attention to the amount of protein in the formula, the type of protein (intact proteins, peptides, and amino acids), and the quality of the protein. Protein quality is dependent on protein digestibility, absorption, and its amino acid composition. Whole egg has the highest biologic value, followed by cow milk, lactalbumin, beef, soy, and casein. Most human liquid formulas contain less than 20% protein calories, precluding their use for the long-term (longer than 3 weeks) feeding of cats. The lower protein formulas should be supplemented with protein modules such as Promod (Ross Laboratories, Columbus OH), Casec (Mead-Johnson, Evansville, IN) or Promagic (Animal Nutrition Laboratories, Burlington, NJ) at 15-30 g casein or whey powder per 8 fl oz. can. Almost all human liquid enteral formulas lack taurine, an essential amino acid in cats, necessitating its supplementation (250 mg taurine per 8 fl oz. can) in this species. High-protein commercial human liquid formulations contain between 21% to 30% protein calories and include Impact (Sandoz Nutrition, Minneapolis, MN), Immun-Aid (McGaw, Inc., Irvine, CA), Alitraq (Ross Laboratories, Columbus, OH), Promote (Ross Laboratories, Columbus, OH), and Traumacal (Mead-Johnson, Evansville, IN).

Commercial blenderized pet food diets should be used for feeding into the stomach via pharyngostomy, esophagostomy, or gastrostomy tubes. In select cases, the feeding of a liquid enteral formulation may be indicated (nasoesophageal or jejunostomy tube feeding). There are a number of complete and balanced veterinary enteral formulations that contain adequate amounts of protein, taurine, and micronutrients, precluding the need for supplementation in most situations. Feeding should be delayed for 24 hours after placing a gastrostomy tube, to allow gastric motility to return, and to allow formation of a fibrin seal. Jejunal feeding can be started within 6 hours of tube placement if peristalsis is present. Continuous feeding must be used with jejunostomy feeding to avoid abdominal cramping and diarrhea associated with bolus feeding via this route. Continuous infusion is recommended at an initial flow rate of 1 ml/kg/hour and increased gradually over 48 hours until the total daily volume can be given over a 12- to 18-hour period. Diet can be administered as bolus feedings or continuous infusion when feeding via gastrostomy tube. Improved weight gain and decreased gastroesophageal reflux have been reported in human patients given continuous feedings, although similar studies are lacking in the veterinary literature. A recent study completed in 10 healthy dogs revealed no significant differences in resulting body weights, serum chemistries, glucose tolerance test findings, hydrogen breath test findings, digestibility trials, or nitrogen balance between dogs fed continuously or intermittently for 10 days. Although no advantage was found with continuous enteral feeding in this study, caution should be exercised in extrapolating these results to sick patients that have been ill for a prolonged period of time and may be more susceptible to gastric atrophy and earlier satiety. If continuous feeding is employed, it should be interrupted every 8 hours to determine the residual volume by applying suction to the feeding tube. If the residual volume is more than twice the volume infused in one hour, feeding should be discontinued for 2 hours, and the rate of infusion
decreased by 25% to prevent vomiting. Treatment with metoclopramide (1 to 2 mg/kg/24 hour as a continuous infusion) may be used to enhance gastric emptying and prevent vomiting.

With bolus feeding, the required daily volume of food should be divided into four to six feeds. Patients are usually fed approximately 25% of their caloric requirement on the first day of feeding, with a gradual increase of 25% of the caloric requirement per day. Most patients are able to reach their energy requirement by the fourth or fifth day of feeding. The food should be warmed to room temperature and fed slowly through the tube to prevent vomiting. Flushing of the tube with 15 to 20 ml of lukewarm water will help prevent clogging. Before each feeding, aspirate the tube with an empty syringe to check for residual food left in the stomach from the previous feeding. If more than half of the last feeding is removed from the stomach, skip the feeding and recheck residual volume at the next feeding.

**Parenteral Nutrition:**

Total (or central) parenteral nutrition (TPN) is the administration of complete energy and protein by intravenous infusion. Specific indications for the use of parenteral feeding include intolerance of enteral feeding as manifested by vomiting or diarrhea, severe malabsorption, severe pancreatitis, or risk of aspiration if the patient is fed via the gastrointestinal tract. The three basic components of TPN formulations are amino acid solutions, lipid emulsions, and dextrose.

**Amino acids:**
Amino acid (AA) solutions serve as the protein source in parenteral nutrition. There are several commercially available AA solutions with a balanced composition of essential and dispensable AA’s. These solutions do not contain taurine. Hepatic and renal formulations are available, but are very expensive. These products differ in their individual AA profiles, available concentrations (4% to 15%), and electrolyte composition.

**Lipid emulsions:**
Fat emulsions serve two primary purposes in the parenteral nutrition regimen- as a source of calories, and as a source of essential fatty acids (EFA’s). Fat is the most calorically dense substrate available, having more than twice the caloric density of carbohydrate and protein, and providing approximately 9 kcal/g. The fat emulsions are typically composed of vegetable oils, phospholipids, and glycerol. As a source of essential fatty acids (EFA), fat emulsions provide varying amounts of linoleic and linolenic acids. Cats cannot convert linoleic acid to arachidonic acid, and should thus receive supplementation with an animal fat source if TPN is administered for longer than 2 weeks. Lipid emulsions are approximately isotonic.

**Dextrose solutions:**
Dextrose is used almost exclusively in parenteral solutions as the source of carbohydrate calories. It is an inexpensive and readily available energy source that is utilized to supply 40 to 60% of the patient’s caloric intake. The provision of carbohydrate calories has been shown to suppress gluconeogenesis from amino acids and is thus protein sparing. Dextrose is commercially available in concentrations ranging from 5 to 70%. In general, parenteral nutrition solutions with a dextrose concentration greater than 10% will necessitate the use of a central venous access to avoid peripheral vein damage.

**Vitamin supplementation:**
Vitamins function primarily as coenzymes of energy-yielding nutrients as well as cofactors in the storage and utilization of energy. Parenteral vitamin requirements in general are significantly less than dietary vitamin requirements because the parenteral route bypasses digestive and absorptive functions of the
gastrointestinal tract. Standard parenteral doses of vitamin B complex should be provided as an additive to the TPN solution upon initiation of parenteral feeding. Concentrations greater than 10% should be administered via central vein because of the vitamins hypertonicity. Fat soluble vitamins should be supplemented if the animal is receiving TPN for > 1 month.

**Peripherally infused PN** is a viable alternative to total PN and is frequently used for the short-term (less than 1 week) nutritional support of patients unable to tolerate enteral feeding. The main advantages of peripherally infused PN over total PN include venous access and ease of provision of estimated nutrient requirements.

Because of the association of venous thrombophlebitis and catheter material, one should choose catheters that are composed of polyurethane or silicone elastomer that appear to have the lowest thrombogenicity. The osmolarity of peripherally infused solutions is generally less than 800 mOsm/L, in contrast to total PN in which osmolarity is often greater than 1200 mOsm/L. The lower osmolarity can be accomplished by providing large amounts of non-protein calories from 20% lipid emulsions (virtually isosmotic), using dextrose solutions of < 20%, and using amino acid solutions of 5%. Electrolytes are typically provided as a component of intravenous fluid therapy; however, trace mineral supplements, particularly zinc at 1μg/kcal, should be added to the PN solution. Potassium phosphate should also be added (approximately 8 mM/1000 kcal) because of the association of hypophosphatemia in patients receiving PN. Vitamin B complex should be added to the PN mix at approximately 2cc B complex/liter PN.

The PN solutions must be mixed in a specific order. Lipid emulsions and dextrose must not be added directly to each other, as the low pH of the dextrose solution may result in instability of the fat emulsion. Therefore, always mix in the following sequence: Dextrose then amino acids then electrolyte and mineral solutions and finally lipids.

After determining the patient’s caloric requirement, one needs to calculate percent protein for the solution. In dogs, one provides 15 to 25% of the caloric requirement as protein, whereas cats are provided with 25 to 35% of their caloric requirement as protein. The remainder of the calories is provided as “nonprotein calories” and the dextrose and lipid contributions are usually split evenly (50:50) in dogs, whereas cats generally receive 40% of the nonprotein calories as dextrose and 60% as lipid. The PN solution is given as a constant rate infusion which can be determined by adding the total amount of each component in ml and dividing by 24.

7. **Evaluate responses and modify as needed:**

Close observation of the patient’s body weight changes, ongoing losses (diarrhea, vomiting, exudative wounds) and physical examination findings (decreased subcutaneous fat stores, muscle wasting, presence of edema or ascites) will help determine whether to increase or decrease the patients caloric intake. Weight changes often reflect fluid dynamics in the early period following injury.