PARENTERAL AND ENTERAL NUTRITION

Parenteral nutrition

Parenteral nutrition consists of the intravenous administration of essential nutrients. Parenteral nutrition is complicated and more expensive compared with enteral nutrition. The way to administer parenteral solution depends on the osmolarity of the solution itself. Very hypertonic (>1500 mOsm/L) solutions must be administered into a large central vein, while solutions of less than 600 mOsm/L may be administered into a peripheral vein.

There are two different ways to administer parenteral nutrition: as partial parenteral nutrition (PPN) or as total parenteral nutrition (TPN). PPN implies administering only essential nutrients intravenously. Usually the solutions for PPN have low osmolarity and can be administered in peripheral veins. TPN implies administering all the nutritional needs intravenously. Solutions for TPN have a high osmolarity, and therefore have to be given through a central vein.

NUTRITIONAL REQUIREMENTS

It is difficult to calculate the energy requirements of ill patients. There are several equations used for this calculation, based on the resting energy requirements (RER), basal energy requirements (BER), or maintenance energy requirements (MER). The most common used equations are based on RER. The resting energy requirements (RER) accounts for the energy required by the animal in a resting state (RER = 70 x BW (kg)^0.75 kcal/day).

Some authors have recommended multiplying the RER with an illness factor (0.5-2.0) to account for hypermetabolism. However this needs to be done with caution, as an excess in caloric intake can be associated with complications. The intent of parenteral support is to provide the resting energy requirement while avoiding complications.

PARENTERAL SOLUTIONS

Parenteral feeding solutions contain crystalline amino acids, emulsified lipids, dextrose and selected vitamins and minerals.

The protein required is estimated separately from the energy requirements. The protein intake varies from 3-8 gr/kg of body weight per day (4-6 gr/kg body weight in cats). Proteins should be restricted in animals with hepatic and renal disorders, and increased in animals with high protein loss (for example with peritonitis or protein loosing enteropathies). Nonproteic calories have been suggested to be distributed as carbohydrates (50-70% in dogs and 20-40% in cats) and lipids (30-50% in dogs and 60-80% in cats). In periods of prolonged anorexia the distribution becomes similar in both species (20-40% of carbohydrates and 60-80% of lipids). Lipids should be administered with care in animals with pancreatitis or hyperlipidemia.

ADMINISTRATION

The solutions must be prepared and administered under sterile conditions through a dedicated catheter, as parenteral solutions provide an ideal growth media for bacteria. Also special nutrient admixture bags and infusion pumps are needed. All compatible components are compounded in sterile nutrient admixture bags, which are used for the administration of the parenteral solution. Parenteral solutions should always be mixed in the following manner--dextrose, amino acids, and lipid, and refrigerated until use (maximum 2 days after preparation).

The parenteral nutrition infusion should begin at one third or half of the calculated requirement. It is administered as a constant rate infusion through a dedicated catheter. If there are no complications with feeding, the rate fed can be slowly increased to reach illness energy requirements by day 3.
**Monitoring**

Periodic routine physical examinations should be performed on all critically ill patients receiving nutritional support. Metabolic complications that may occur include hyperglycemia, glucosuria, hypo-or hyperkalemia, hypophosphatemia and hyperlipemia. These may necessitate adjusting the parenteral nutrition components, slowing the rate of infusion, or specific treatments for each abnormality (for example administering insulin or potassium). Daily evaluation of the parenteral nutrition formula is essential.

The most serious (but uncommon) complication is catheter or solution related sepsis. To prevent this problem the catheter must be checked daily and changed if necessary. The animal should be only disconnected from the CRI when absolutely necessary and all the components of the administration system should be changed daily.

The packed cell volume, total protein, blood urea nitrogen, serum electrolytes (sodium, potassium, chloride, ionized calcium), venous blood gas and blood glucose concentrations should be monitored every 6 to 12 hours. Serum triglycerides and ammonia concentrations should be determined daily.

**Enteral Nutrition**

Nutrition is a very important component of patient management especially in the critical care setting. If the gastrointestinal tract is functioning, enteral nutrition is the most appropriate choice. It is also the most cost-effective choice.

Most feeding tubes are made of polyurethane or silicone. Polyurethane is stronger than silicone (allowing 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. The French (F) unit measures the outer lumen diameter of a tube (each French unit is equal to 0.33 mm).

**Indications:**
- Significant anorexia (>5 days), significant weight loss (>10%), increased nutritional losses, increased nutritional requirements, anticipated loss of appetite, bypass of specific parts of alimentary canal

**Nasogastric tube:** Simple and efficient choice for the short-term (less than 10 days). This method is contraindicated in animals that are vomiting, comatose, or lack a gag reflex. The tube should reach the distal esophagus rather than the stomach (nasogastric tubes increase the risk of reflux esophagitis and stricture formation). Usually only topical installation of a local anesthetic to desensitize the nasal cavity is necessary. The tip of the tube should be lubricated and passed in a ventromedial direction. Advancement of the tube into the pharynx usually elicits a swallowing reflex. It should be secured as close to the nostril as possible, and on the dorsal midline between the eyes, with either suture material or superglue. An Elizabethan collar should be placed. The tube position needs to be checked (injecting 5 to 10 ml of air while auscultating the cranial abdomen for borborygmus, 3 to 5 ml of sterile saline and observing for a cough response or by obtaining a lateral survey thoracic radiograph)

Advantages: Inexpensive, non-invasive, quick, equipment readily available

Disadvantages: small diameter (liquid enteral formulas), short periods of time

**Pharyngostomy tube:** Not well tolerated by most animals. Should be avoided. Pharyngostomy requires general anesthesia and meticulous attention to placement to avoid interference of epiglottic movement and partial obstruction of the larynx.

**Esophagostomy tube:** The tubes are easily inserted, but insertion requires general anesthesia. Daily meticulous care of the ostomy site has been effective in preventing wound infection at the ostomy site.
Several 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 easiest technique is to use Carmalt forceps and pass them per os. The tips of the forceps can be palpated in the mid-cervical esophagus and a cutaneous incision is made until the tips are visualized. The feeding tube is pulled out the mouth and reversed into the esophagus. The tube is fixed in place with a friction suture or a tape “butterfly”. The tube is capped and bandaged. The ostomy site is allowed to heal by granulation and epithelialization when the esophagostomy tube is removed. Esophageal stricture or a persistent esphagocutaneous fistula is very unlikely to happen.

Advantages: Inexpensive, large tube, quick, well tolerated

Disadvantages: Invasive, fistula formation

Gastrostomy tube: Requires general anesthesia, with placement of the tube via percutaneously (endoscopically/PEG or blind techniques/BPG) or during laparotomy. A surgical approach is indicated in obese patients, patients with esophageal obstruction, or when the patient requires a laparotomy. This procedure enables placement of relatively large diameter catheters into the patient’s stomach. 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.

For percutaneously placed tubes, it is recommended that the tube be left in place for a minimum of 14–21 days (for a peritoneal seal to form), and only removed when the oral food intake is sufficient. One of two methods of tube removal can be applied. The tube can be cut at the body wall and the mushroom tip pushed into the stomach to be passed in the feces (in mid- to large-size dogs). Alternatively, a stylet can be inserted into the tube to flatten the mushroom tip, while exerting firm traction on the tube (especially in cats and small dogs). The gastrocutaneous tract should seal with minimal or no leakage within 24 hours. Removal of a gastrostomy tube before 14–21 days of placement necessitates a PEG procedure to evaluate the gastric mucosa and verify correct positioning of the replacement gastrostomy tube. If the tube is inadvertently removed once the gastrocutaneous tract is well healed, one can replace the original catheter directly.

Advantages: Large tube, well tolerated

Disadvantages: Cost, equipment, invasive, peritonitis, may cause vomiting and gastroesophageal reflux

Jejunostomy tube: This technique requires surgery. Most often this tube is placed via laparotomy. The enterostomy site is fixed to the abdominal wall with interrupted or continuous sutures passing through the intestinal submucosa and abdominal fascia. Jejunal feeding can be started within six hours of tube placement.

Advantages: Distal GI tract, well tolerated

Disadvantages: Cost, invasive, peritonitis, small tube size (liquid diet)

Tube maintenance: Most tubes require low maintenance. The tube sites must be kept clean and bandaged enough. Tubes should be routinely flushed following feeding to prevent blockage. If blockage occurs flushes with warm water, coke or pancreatic enzyme may be useful.

Diet Selection: 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. Generally blenderized diets are the most cost effective and work well in larger
bore tubes (pharyngostomy, esophagostomy, or gastrostomy tubes). In small bore tubes (nasoesophageal or jejunostomy feeding tubes) commercially available liquid diets can be used. Most commercially available liquid diets have a caloric density of approximately 1 kcal per ml. Blenderized commercial diets can also be diluted, but energy density may be a problem (obstructions).

Diet can be administered as bolus feedings or continuous infusion. Continuous infusion is recommended at an initial flow rate of 1 ml/kg/hour and increased gradually over 48 hours to meet requirements. With bolus feeding, the required daily volume of food should be divided into four to six feeds. Patients are usually fed approximately 1/4 of their caloric requirement on the first day of feeding, with a quarter increase every day (complete caloric requirements after 4 days). The stomach capacity should never be exceeded (90ml/kg for dogs and 45 ml/kg for cats). The food should be given slowly and at room temperature to prevent vomiting. The tube should be flushed with 15 to 20 ml of water to 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 skip the feeding and adjust the volume for the next feeding).