

Critical Care of the Dog



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Key Points

- Critically ill patients are in a very unstable and dynamic phase of change.
- The effect of starvation is different and more severe in stressed animals compared to normal pets, and malnutrition can occur within a number of days.
- Protein-calorie-malnutrition can have severe effects on the major organ systems, including muscles, the gastrointestinal tract and the immune system, possibly even leading to bacterial translocation and septicemia.
- Identifying patients that benefit from nutritional support is important and is based on patients' history, physical examination, and laboratory results.
- The provision of nutritional support plays a crucial role in the rapid and successful recovery of critically ill patients.
- The energy intake of critically ill patients needs to be monitored closely, supplying a minimum level of resting energy requirement and adjusting this as appropriate.
- Energy needs to be provided in form of high quality protein and fat.
- Other nutrients of interest are specific amino acids like arginine, glutamine, and branch chained amino acids, as well as B vitamins and zinc.
- There are a variety of methods for nutritional support, ranging from assisted feeding to a number of different feeding tubes for enteral and parenteral feeding.
- Enteral feeding is the safest, most physiological and most cost effective way to supply nutrients, and the gut should be used whenever possible.
- Patient monitoring includes daily physical examination with twice daily body weight checks and laboratory values, such as total proteins, albumin, PCV, blood glucose, blood urea nitrogen, and urine specific gravity.

Dogs in a “critical” state are by their very nature unstable and in a dynamic state of change. However, once immediate life-threatening problems such as hemorrhage, shock, or other organ failures are stabilized, the provision of nutritional support is essential to a rapid and successful recovery.

It has been estimated that up to 50% of hospitalized small animal patients are malnourished (Chandler et al. 1992). Dogs that have suffered a traumatic incident or debilitating illness enter a stressed or hypermetabolic phase in which tissue proteins are catabolized in order to provide building blocks for life-saving functions such as antibody production, wound healing, and gluconeogenesis for maintenance of energy levels. During periods of starvation, the healthy dog is able to adjust its metabolic rate accordingly by lowering metabolic demands and activity. In the critically ill dog, however, which will not or cannot eat to replenish these increased energy demands, the onset of malnutrition can occur within three to five days. Providing nutritional support to these patients can be very rewarding with numerous well established benefits.

Effect of Starvation in “Normal” and “Stressed” Animals		
<i>Metabolic parameter</i>	<i>Normal</i>	<i>Stressed</i>
Energy expenditure	Decreased	Markedly increased
Primary fuels	Glucose, fat, ketones	Fat, glucose, proteins
Gluconeogenesis	Increased	Markedly increased
Protein synthesis	Decreased	Decreased or increased
Protein catabolism	Increased	Markedly increased

COMMON CAUSES OF CRITICAL ILLNESS IN DOGS

There are a number of different causes that may lead to critical illness in patients. However, the supportive treatment and the nutritional support may be very similar for these patients.

- Trauma
- Neoplasia
- Anemia
 - Hemolysis
 - Hemorrhage
 - Bone marrow failure
- Organ failure
 - Heart
 - Liver
 - Kidneys
 - Lungs
- Endocrinopathies
 - Diabetic ketoacidosis
 - Hypoadrenocorticism
- Sepsis/Infection
- CNS disease
- Toxins
- Immune-mediated disease

BENEFITS OF NUTRITIONAL SUPPORT

The therapeutic benefits of nutritional support in critically ill patients are well established:

- Decreased morbidity and mortality
- Improved tolerance to invasive procedures
- Shorter hospitalization periods
- Decreased incidence of infections
- Earlier ambulation
- Rapid wound healing
- Fewer complications

RESPONSE TO INJURY

Critically ill dogs, which are unable or unwilling to eat, must rely on their endogenous stores to supply energy and protein for recovery.

Glycogen reserves in the liver are mobilized but are quickly depleted within the first 12 to 24 hours. Thereafter glucose must be synthesized from lactate, glycerol, and amino acids to provide fuel for those obligate tissues, which require glucose for energy such as the brain and kidney. Lipids are mobilized from adipose stores and metabolized to ketones, which may be used as an energy source in some tissues.

There are no storage forms of protein in the body and therefore, endogenous muscle proteins are catabolized to energy. It is this subsequent negative nitrogen balance that can lead to protein-calorie malnutrition and is most difficult for the critical patient. The demand for new proteins in healing and replacement tissues is high and a lack of amino acids results in delayed healing and decreased production of defense proteins such as immunoglobulins, clotting factors, and acute phase reactants.

Furthermore, these adaptive processes in the critically ill patient are not as efficient due to excess stress hormones, such as glucocorticoids, catecholamines, and vasoactive substances such as cytokines, and other inflammatory mediators.

Providing an animal with nutritional support may soften this hypercatabolic response to injury and preserve endogenous tissue resources. And in chronically ill patients with longstanding malnutrition, nutritional support may be vital to recovery and survival.

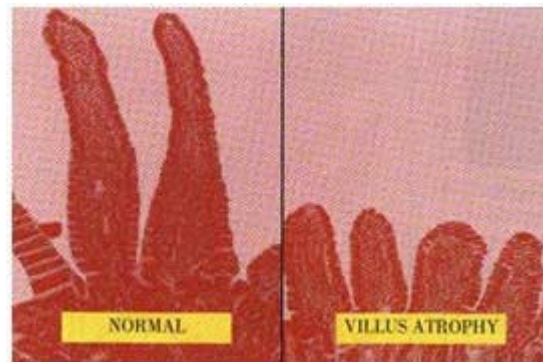
CLINICAL CONSEQUENCES OF PROTEIN-CALORIE-MALNUTRITION

Prolonged protein-calorie malnutrition affects every major organ system, and this process is further accelerated in the hypermetabolic patient. Failure to provide nutritional supplementation to critically ill dogs may lead to the induction of multiple organ failure, and can be directly related to morbidity and mortality. The consequences of poor nutritional status may affect individual organ systems or conditions, including:

- Gastrointestinal tract
- Muscle
- Liver
- Kidneys
- Cardiopulmonary tract
- Immune system
- General recovery

Gastrointestinal Tract

The amino acid glutamine is the primary energy source of rapidly dividing cells, including enterocytes. A deficiency of glutamine results in small intestinal villus atrophy and a compromise in the mucosal barrier, which may ultimately lead to bacterial translocation and sepsis. Brush border enzymes, which aid in digestion, down-regulate their own activity, making the digestive process much less efficient.



Muscle

Protein stores are mobilized, reducing muscle strength and mass, resulting not only in weight loss and weakness of the skeletal muscles, but also in deterioration of smooth and cardiac muscles.

Liver

Impaired function of the reticuloendothelial system allows bacteria in the portal system access to general circulation, thus increasing the risk of sepsis; this is particularly dangerous in combination with decreased antibody production due to protein malnutrition.

Glycogen stores become depleted, as do the amino acid building blocks necessary to meet the protein demands of the stressed patient, which may lead to hypoproteinemia, decreased wound healing, third-spacing of fluid, and edema.

Immune System

Decreased antibody production, impaired chemotaxis, phagocytosis, and oxidative/respiratory burst of white blood cells further increase the risk of infections and sepsis. Death may result despite the use of powerful and expensive antibiotics.

Kidneys

Patients may develop a diminished capacity for renal gluconeogenesis, amino acid metabolism, and regulation of acid-base balance.

Cardiopulmonary Tract

Critically ill, malnourished dogs may show compromised gas exchange and acid-base balance, decreased metabolism of hormones and surfactant.

General Recovery

These patients may show increased susceptibility to shock, delayed wound, and fracture healing, increased incidence of dehiscence and visceral wound leakage, and diminished tolerance to hospital stress. Recovery may therefore be delayed.

PATIENT SELECTION

In human medicine, multiple parameters are used to assess the patient's need for nutritional support including anthropomorphic measurements, clinical nutrition history, and analytical laboratory measurements. In veterinary medicine, there are fewer practical and less reliable means of determining which patients require nutritional support. There is no "gold standard" test; however, a combination of the following subjective and objective means of assessment are often helpful to identify those patients in need of nutritional support.

Subjective assessment: history and physical examination

- Previous history of illness or weight loss
- Current poor body condition or acute loss of >5% body weight
- Dogs that have been anorexic or inappetent for >3 days (real or anticipated)
- Severity and nature of injuries which prevent adequate oral intake:
 - Facial injuries
 - Prolonged or unmanaged pain
 - Injuries requiring surgical correction
 - Conditions of excessive protein loss (peritoneal drainage; open, discharging skin wounds; liver or renal failure; protein-losing nephropathy or enteropathy)

Objective assessments: laboratory results

- Lymphopenia
- Low serum albumin; hypoalbuminemia
- Low creatine kinase; nonspecific increase in the absence of muscular disease or damage
- Decline in total iron binding capacity (TIBC)
- Low transferrin
- Serum insulin-like growth factor 1 (IGF-1)

NUTRITIONAL REQUIREMENTS

The nutrient requirements of critical patients have not been clearly determined, however, normal dietary constituents should be adjusted to suit the animals' disease requirements including energy, fat, carbohydrate, and protein. Additionally, there are many other essential nutrients including select amino acids, minerals, and vitamins, but it is yet not fully determined how critical illness will affect these micronutrient requirements. A number of specific nutrients have properties that may be beneficial in the nutritional management of critical care patients, including glutamine, arginine, branched chain amino acids, B vitamins, and zinc.

Energy

The calculation of energy requirements of critically ill patients is difficult to establish and has therefore been subject of some controversy. As it is usually not possible to measure the patient's energy consumption directly, equations have been established to estimate the requirement. Recommendations have been made using either resting energy requirements (RER), basal energy requirements (BER), or maintenance energy requirements (MER).

Basal energy requirements describe the energy that is needed to keep the body "ticking over," (i.e., the energy to meet the needs of cells and organs under certain set conditions, such as a thermoneutral environment, no stress, and 12 hour dietary rest). The resting energy requirements (RER) involve the energy required by the animal in a resting state and account for physiologic influences and the assimilation of nutrients. The maintenance energy requirements (MER) encompass all the energy required for maintaining normal body condition in a normal pet.

$$\begin{aligned} \text{BER} / \text{RER} &= 70 \times W^{0.75} \text{ kcal/day} \\ \text{MER} &= 110 \times W^{0.75} \text{ kcal/day} \end{aligned}$$

Many authors recommend using either RER or MER and multiplying these with an illness factor to account for extra hypermetabolic requirements. It has been suggested that critically ill patients have requirements ranging from 0.5-1.5, possibly 2.0 x RER/MER (Wills and Simpson 1994, Buffington 1998, Murtaugh 1998).

Other authors suggest that the RER of critical patients, determined with indirect calorimetry, indicates that their energy expenditure is only slightly increased from normal (Thatcher 1998). Additionally, feeding excessive calories may have a number of negative effects, such as gastrointestinal problems, electrolyte imbalances and hepatic dysfunction (Lippert et al. 1989), and it is generally recommended to avoid overfeeding and associated complications (Buffington 1998).

The practical recommendation is to ensure that all patients that require nutritional support are fed at a minimum level of their RER. Close monitoring of the patient's body weight and body condition can then be used to help to adjust the calorie intake for each individual patient, and this may mean increasing RER as discussed above.

Calories are provided by a balance of fat, protein, and carbohydrates.

Fat

High fat diets have been recommended in the feeding of critical patients because triglycerides rather than glucose provides the principal fuel for increased metabolism in the catabolic patient. Fat provides more than twice the energy density per unit weight than protein or carbohydrates, and increasing the fat level will help to make a diet more concentrated. In the stressed or traumatized patient, the administration of reduced volumes of highly energy dense foods may be critical, as feeding lower volumes means less stress to the patient.

High fat diets also tend to be more palatable and digestible, and patients are more likely to begin eating sooner on their own.

Carbohydrates

There is no individual requirement for carbohydrates other than as an alternate and readily available source of energy other than fat. Supplementation with carbohydrates helps to preserve endogenous protein from breakdown and subsequent conversion to glucose via gluconeogenesis. Oversupplementation of simple carbohydrates such as glucose, however, can predispose patients to hyperglycemia. The resultant excessive release of insulin can lead to hypophosphatemia, hypokalemia, and other metabolic derangements.

Complex indigestible carbohydrates such as fiber are rarely included in diets formulated for critical care, as fiber may increase the feeding volume, reduce the overall digestibility and decrease the availability of essential nutrients, such as zinc.

Protein

Protein requirements can increase significantly in the critical patient. The amount of protein required reflects the number of amino acids needed for protein synthesis. This is determined by the amino acids required to replace those that have been degraded in the catabolic process, those lost due to trauma or injury, and those required for the build-up of new body tissue.

To abolish negative nitrogen balance in a severely hypermetabolic and hypercatabolic patient, it is necessary to supply protein in amounts considerably in excess of normal minimum requirements (Bursztein et al. 1989); however, because of risks associated with overfeeding hospitalized patients, a more moderate approach is recommended. For enteral feeding in dogs, protein should comprise at least 20-30% of calories (2 to 3 g/kg BW). To maintain wound healing and immune function in severe protein-losing disease conditions such as extensive burns or peritoneal drainage, as much as 25-48% of the metabolizable energy (ME) may be needed in form of protein (Wills and Simpson 1994). Dietary restriction of protein, however, may be indicated in individuals with certain concurrent conditions such as portosystemic shunts, chronic kidney or liver disease; in these critically ill patients, protein intake needs to be carefully balanced.

The dietary source of protein should be highly digestible and contain all the essential amino acids, such as those found in egg and milk proteins.

Essential Amino Acid Requirements for Maintenance

<i>Amino Acid</i>	<i>Dog^a</i>	<i>Cat</i>
Arginine	68	478 ^b
Histidine	71	ND
Isoleucine	155	ND
Leucine	271	ND
Lysine	161	158 ^c
Methionine and cystine	97	155 ^c
Phenylalanine and tyrosine	277	ND
Threonine	142	ND
Tryptophan	42	ND
Valine	193	ND

ND = No research data.

^aData from NRC (1985).

^bData from NCR (1986) for the near-adult cat.

^cData from Burger and Smith (1990).

Branched Chain Amino Acids

Branched chain amino acids (BCAAs) are thought to have a beneficial effect on nitrogen balance. Studies have documented an increase in nitrogen retention and hepatic protein synthesis when BCAAs are supplemented in the traumatized or stressed patient. A decrease in the ratio of BCAAs to aromatic amino acids has been implicated in the development of encephalopathy in septic patients but not proven (Skeie et al. 1990). A definitive need therefore for BCAA supplementation has yet to be defined in the critically ill patient.

Glutamine

Glutamine is a ubiquitous amino acid, which is found in abundant quantities in blood and other tissues. This amino acid has multiple functions including:

- Playing a role in acid-base balance
- Being a precursor of purine and pyrimidine nucleotides
- Playing a role in detoxification
- As a nitrogen carrier between tissues
- As a regulator of hepatic protein synthesis
- As a respiratory fuel in certain tissues

The role of glutamine as an important and major substrate in rapidly dividing cells, such as those of the gastrointestinal tract and the immune system (lymphocytes, macrophages, and thymocytes), is well known. Glutamine is responsible for maintaining the IgA-secreting cells of the gut mucosa, and an adequate supply is therefore required to ensure the integrity of the intestinal mucosal barrier.

Glutamine is a nonessential amino acid in the dog; however, during stress or trauma, the synthesis of glutamine is not sufficient to match the increase in uptake and metabolism by the gastrointestinal tract. Glutamine has therefore been described as a “conditionally essential amino acid” (Lacey and Wilmore 1990, Mobrahan 1992). This increased demand and concurrent poor supply in trauma patients may result in a compromise of the gut mucosal barrier, with subsequent bacterial translocation and systemic infection (Souba et al. 1990). Specific recommendations for levels of this amino acid in critical patients are lacking; however, the benefits of supplementation have been demonstrated (Souba et al. 1990). Milk protein is a rich source of glutamine.

Arginine

Arginine is an essential amino acid in the dog, but not in humans. Arginine has been shown to enhance cellular immunity, wound healing, and nitrogen balance (Barbul 1986). There are no specific indications for this amino acid in the traumatized or stressed dog; however, as requirements for arginine may be increased in the critically ill patient, a level of arginine to support normal growth is recommended in diets intended for these patients.

B Vitamins

Although specific levels have not been determined for the critically ill dog, water-soluble B-complex vitamins may have an increased requirement in the hypermetabolic patient due to fluid losses and increased energy expenditure. B vitamins are not stored in the body; subsequently, they may be easily diluted and depleted in the anorexic or inappetent critical patient. Fortunately, they are easily replaced in fluids or in well-balanced enteral or parenteral formulas.

Thiamin

<i>Vitamin</i>	<i>Function</i>	<i>Imbalance Causes</i>
Thiamin (Vitamin B1)	Involved in carbohydrate metabolism. Requirement is dependent on the carbohydrate content of the diet.	Deficiency - Anorexia, neurologic disorders (especially of the postural mechanisms) followed ultimately by weakness, heart failure, and death. Can occur, especially in cats, as a result of feeding large amounts of certain types of raw fish, which contain the enzyme thiaminase. In addition, the vitamin is progressively destroyed by high temperatures and under certain conditions of processing. Toxicity - Low toxicity.

Zinc

Zinc may be important to the hospitalized patient by virtue of its role in protein and nucleic acid metabolism and in promoting wound healing. Zinc deficiency can result in impaired protein synthesis, increased protein catabolism, depressed wound healing and depressed immune function. Although it is difficult to establish zinc status from circulatory levels, a decrease in plasma zinc level is observed following injury (McClain et al. 1986). This has been attributed to a combination of increased urinary zinc loss and tissue redistribution of zinc. It has therefore been suggested that zinc supplementation may be beneficial in the critical canine patient.

Methods of Supplementation

Anorexia and inappetence are common in the critical patient. Normal voluntary feeding is the preferred means of supplementation, as it is the least stressful method for both patient and caregiver.

Initial attempts to increase palatability of the food may include providing small, frequent meals of wet, warmed, odiferous foods. Assisted feeding may be attempted by gently syringing a liquid food into the corner of the patient's mouth. It is, however, important not to stress the patient excessively while force-feeding.

Appetite stimulants may be used initially to help "jumpstart" the appetite; however, if the dog refuses these efforts, nutritional support may be supplemented via the gastrointestinal tract (enteral feeding) or by intravenous infusion of an energy-dense solution (parenteral feeding).

Appetite Stimulants

<i>Drug</i>	<i>Dose</i>	<i>Side Effects</i>
Diazepam	1-2mg IV, IM or PO per cat	Sedation, idiosyncratic liver necrosis
Oxazepam	5-10 mg PO BID per cat	Same as diazepam
Cyproheptadine	8 mg/m ² or 2-4 mg/cat PO 5-20 mg/dog PO	Excitability, aggression, vomiting
Steroids		
Nandrolone	5 mg/kg IM weekly (dogs)	Uncommon
Stanozolol	1-2 mg PO BID (cats) 1-4 mg PO BID (dogs)	Uncommon
Prednisolone	0.5-1 mg/kg (cats & dogs)	Polyuria/polydipsia, decreased wound healing, may interfere with therapy for disease

Enteral Feeding

Enteral feeding is considered more physiologically sound than intravenous feeding, as it maintains the health of the gastrointestinal tract; therefore, if the gut works, use it!

The intact intestinal mucosa acts as an important barrier to bacteria, and it is therefore important to maintain the health of the gastrointestinal lining by supplying nutrients enterally. When the gut is starved, bacteria can translocate from the intestine into the circulation, leading to sepsis; therefore even patients receiving parenteral nutritional support may benefit from enteral feeding (Wills and Simpson 1994).

Routes of Enteral Nutritional Support

<i>Method</i>	<i>Advantage</i>	<i>Disadvantage</i>
Assisted feeding	Simple, less stressful	Not effective in many patients
Chemical stimulants	Simple, "reminds" patient of the taste of foods	May induce sedation Short term (2-3 days)
Nasoesophageal tube (3.5-5 Fr, cat) (3.5-8 Fr, dog)	Easy to place, least invasive Minimal sedation required Use up to one week Low cost	Not always well tolerated Must use an Elizabethan collar
Pharyngostomy tube (12-18 Fr, dog)	No special equipment required Can be used long term	Requires general anesthesia Malpositioning may lead to aspiration

Enteral feeding is most often accomplished by use of feeding tubes, which are ideally placed as proximally as the animal's clinical state and temperament will permit. These include nasoesophageal, pharyngostomy, esophagostomy, gastrostomy and enterostomy feeding tubes. The utilization and care of these tubes is usually straightforward with few complications.

Nasoesophageal Tube Feeding

This is an excellent option for short-term feeding (<14 days) of hospitalized patients. Most patients will tolerate this kind of tube very well, provided it is protected by an Elizabethan collar. Placing a nasoesophageal feeding tube involves choosing a tube that will fit snugly into the ventral meatus and passing it to the level of the lower esophageal sphincter. Most critically ill patients will tolerate tube placement, but some individuals may require sedation.

The tube is secured in place with sutures at the nares with one or two others as needed on the face and head. Tubes passed into the stomach may allow for reflux of acid juices, causing esophagitis and contributing to vomiting and irritation; it is therefore recommended to place the tube end into the esophagus.



Dog with nasoesophageal tube wearing an Elizabethan collar

Contraindications for the use of nasoesophageal tubes include patients that have had severe facial trauma involving the nares, those that are already experiencing protracted vomiting and/or regurgitation, animals that are semiconscious, or those patients that have laryngeal, pharyngeal, or esophageal physical or functional abnormalities.

Pharyngostomy Tube Feeding

Pharyngostomy tubes are placed into the pharynx under a general anesthetic and threaded down into the esophagus. These should not be used in smaller dogs (<10 kg BW) due to the limitations of space and potential interference with laryngeal function. With the advent and simplicity of gastrostomy and esophagostomy tube placement, pharyngostomy tubes are used less frequently.

Esophagostomy Tube Feeding

These are large bore tubes that can be easily placed under a light anesthetic with minimal equipment requirements in dogs of all sizes. 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.

Gastrostomy Tube Feeding

Gastrostomy tubes have become invaluable for the long-term nutritional support of critically ill patients. Gastric feeding tubes may be placed surgically, endoscopically or by a “blind” percutaneous technique. As with other ostomy tubes, they must remain in place for a minimum of 7-10 days to allow a seal to form with the abdominal wall. These tubes may be easily maintained for many weeks to months in the chronically ill or anorexic patient. Most patients tolerate the tubes quite well as long as the site of entry is adequately wrapped to prevent the wound from becoming infected, and Elizabethan collars are fitted to prevent the dog from inadvertently removing the tube prematurely.

Enterostomy Tube Feeding

The placement of feeding tubes beyond the stomach is rarely indicated, but in cases of pancreatitis, diffuse gastric mucosal disease, protracted vomiting or delayed gastric emptying, an enterostomy tube may be life-saving. Enterostomy tubes are most commonly placed surgically, although they may be alternatively introduced via a gastric tube and then directed down through the pylorus with an endoscope.

Contraindications include ascites, peritonitis, immunosuppression and distal small bowel obstructions.

Feeding through an enterostomy tube must be facilitated by a continuous infusion pump due to the narrow diameter of the tube and the volume necessary to meet energy demands.

The Care and Use of Enteral Feeding Tubes

- Once in place, the accurate placement of feeding tube should be checked (e.g., by flushing the tube with sterile water or taking a radiograph).
- Gastrostomy and enterostomy tubes should not be used for the first 24 hours to allow a seal to form with the body wall.
- Liquid concentration diets may be used for all sizes of feeding tubes; with very small tubes (>8 Fr), diets may have to be blenderized further with water to allow passage.
- One-third of the calculated energy requirements is divided into several (4-6) small feedings (5-20 ml, depending upon the size of the dog) and administered through the tube on the first day.
- The food is warmed to body temperature and injected slowly over several minutes; if the patient begins to retch or swallow, slow down the rate of administration.
- The tube must be flushed with 3-5 ml of water before and after each feeding to clear debris and maintain tube patency; should the tube become blocked, a cola product or enzymatic solution may be incubated in the tube overnight to help clear organic debris; if the tube remains blocked, it should be replaced.
- The volume of feedings are increased by one-third each day until the patient is able to tolerate its full caloric intake; once the patient has been on full feedings for several days the volume of each feeding may be increased, and the frequency of meals decreased.
- For gastrostomy tube feedings, the tube should be aspirated prior to each feeding to ensure that the stomach has emptied; if gastric emptying is delayed, and more than half of the previous meal persists, skip the next feeding.
- Gastrostomy and enterostomy tubes must be wrapped, the wounds cleaned and bandages changed every two to three days as necessary.
- Elizabethan collars should be used to prevent inadvertent removal of the tubes.

Parenteral Feeding

Parenteral feeding is the administration of essential nutrients (fat, carbohydrates, and protein, vitamins and minerals, and water) by continuous intravenous infusion. This is also called total parenteral nutrition (TPN). TPN should be used only when enteral nutrition is not possible due to severe gastrointestinal dysfunction, since its application can be fraught with potentially fatal complications, and the feeding solutions can be both expensive and difficult to obtain. When solutions designed for use in humans are applied, supplementation with essential amino acids such as arginine is necessary; also, protein levels ought to be adjusted to canine requirements

Potential Complications arising from TPN ***Sepsis***

The nutrient-rich solutions provide an ideal growth media for contaminating bacteria. Therefore, to prevent transferring infections, these solutions must be mixed and administered under sterile conditions through a dedicated catheter, preferably in the jugular vein, which is cared for meticulously.

Additionally, there may be an increased risk of bacterial translocation and subsequent sepsis from the gastrointestinal tract. The intact intestinal mucosa acts as an important barrier to bacteria, and when the gut is starved, bacteria can translocate from the intestine into the circulation; therefore, even patients receiving parenteral nutritional support may benefit from concurrent enteral feeding (Wills and Simpson 1994).

Metabolic Derangements

The nutrients in the solution are concentrated to provide as much dextrose, lipids, and amino acids as necessary to maintain an adequate nutritional plane. However, the patient may not be able to quickly assimilate these nutrients, leading to problems such as hyperglycemia, glucosuria, hypo- or hyperkalemia, and lipemia which may necessitate adjusting the nutrient ratios, slowing the rate of infusion, or administering insulin or potassium supplements.

Monitoring

Routine physical examinations including body temperature, heart rate, respiratory rate, twice daily weight measurements, assessment of hydration status, and attitude should be performed on all critically ill patients receiving nutritional support.

Laboratory values frequently assessed include total proteins, albumin, packed cell volume, blood glucose, blood urea nitrogen, and urine specific gravity. Alterations in these parameters may indicate improved patient status due to correction and support of the underlying disease or, conversely, may signal early warnings of complications associated with nutritional support.

SUMMARY

Care of the critically ill dog is greatly improved with an understanding of the patient's response to injury, the metabolic consequences, and the assessment of nutritional status with the skills to provide appropriate nutritional support. Prolonged protein-calorie malnutrition affects every organ system in the critically ill animal, may lead to the induction of multiple organ failure, and is directly related to morbidity and mortality.

The provision of energy and nutrients in the form of fat, protein, carbohydrates, and selected minerals and vitamins should be considered a high priority once the immediate life-threatening problems have been addressed. Nutritional support plays a significant role in softening the consequences of hypermetabolism, which drains endogenous stores of nutrients, and thus allows for a smoother recovery with fewer complications in the critical patient.

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