Parenteral Nutrition

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New Article Series

Patient Support is a new column that outlines optimum strategy and intervention for providing the best patient-centered veterinary care while pursuing curative medicine and surgery.

Definition

Parenteral nutrition (PN) is nutrition delivered by the intravenous route; other routes, such as the intraosseous route, are used in rare cases.

Indications

PN can be life-saving in patients that cannot tolerate enteral feeding. However, because there are drawbacks associated with this form of nourishment, it should be reserved for patients that have no other feeding options and for which nourishment is critical for recovery. PN is indicated for patients that need assisted feeding for which enteral nutrition is contraindicated. For example:

- Patients at risk for pulmonary aspiration require PN if they cannot be safely fed via a gastrostomy or enterostomy tube.
- Patients that have gastrointestinal disease (eg, intractable vomiting, ileus, acute pancreatitis) to the extent that they are unable to tolerate enteral feeding need PN if the source or location of gastrointestinal tract dysfunction cannot be bypassed with a feeding tube.

PN is also indicated for patients that need assisted feeding for which enterally supplied nutrition is insufficient—for example, when enteral intake cannot be tolerated to the extent necessary to meet the patient's nutritional requirements or the patient has gastrointestinal conditions that compromise digestion and/or absorption of food. Enteral intake in these cases can be supplemented through parenteral feeding.

Assessment

The three technical requirements for safe administration of PN are:

1. The ability to obtain and maintain venous access.

- PN must be delivered through a dedicated catheter to avoid the potential for septic complications or drug-nutrient interactions. The PN catheter (or port of a multilumen catheter) cannot be used for delivery of anything else to the patient (eg, fluids, medications, blood products), for monitoring purposes, or for blood sampling.
- PN catheters must be placed aseptically using surgical preparation of the insertion site and sterile draping and gloves.

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- Ideally, PN admixtures are delivered through a centrally placed line because many of the components of PN are hyperosmolar (see **Tables 1 and 2**) and need to be greatly diluted to allow successful administration through a peripheral catheter.
- Patients should be assessed for conditions that could contraindicate use of a jugular central catheter, including diseases that may increase intracranial pressure or cause a hypercoagulable state (eg, protein-losing nephropathy or enteropathy, hyperadrenocorticism, disseminated intravascular coagulation). In such circumstances, a peripherally inserted central catheter in a hindlimb can be substituted for the jugular catheter.

2. The ability to formulate and prepare the nutrient admixture.

- To prepare a PN admixture, you need a prescription for the formulation (see **Application**, page 14), the required nutrient solutions, and knowledge of how to safely compound the admixture.
- For practices that have an intensive care unit with a high caseload, it may be convenient to keep the requisite materials for compounding PN in stock so it can be prepared in-house. However, for many practices it is much easier to establish an arrangement with a local human hospital or home infusion service so that PN can be ordered as needed without the necessity of maintaining an inventory of special supplies or having to train personnel in compounding techniques.
- While no parenteral nutrient products are manufactured specifically for companion animals, the human products can be used safely. When used in recommended amounts, conventional human amino acid solutions meet all the essential amino acid requirements of dogs and cats, with the exception of taurine.
- Pediatric amino acid solutions containing taurine are available, but clinical experience with these products in cats is lacking.

3. The ability to monitor the patient during PN delivery, including the ability to perform point-of-care serum chemistry.

- Ideally, PN should be delivered as a constant-rate infusion 24 hours per day. Consequently, round-the-clock monitoring and nursing care must be available.
- Metabolic abnormalities, including hyperglycemia, hyperlipidemia, and electrolyte fluctuations, are common in patients receiving PN. These complications are sometimes serious enough to be life-threatening. Therefore, the ability to do in-house serum chemistry is required to facilitate frequent and timely monitoring of serum glucose and electrolytes.

Components that are included in the nutrient admixture are protein (amino acids), dextrose, lipids, electrolytes, and micronutrients such as vitamin B complex.

How to Estimate Resting Energy Metabolism

Use actual weight unless the patient is significantly overweight (eg, body condition score > 6/9 where 4 to 5/9 is optimal), in which case a conservative estimate of the patient's ideal weight should be used.

Resting energy metabolism (RER) can be estimated for dog and cats by using either of the following formulas:

$$\mathbf{RER = 70Wt_{kg}^{0.75}}$$

For patients weighing > 2 kg and < 30 kg:

$$\mathbf{RER = 30Wt_{kg} + 70}$$

Application

The five steps of formulating the nutrient admixture are:

1. Calculate the day's caloric goal.

- Use the patient's resting energy expenditure for the initial caloric goal and adjust based on whether the patient maintains or loses weight over the course of several days (see **How to Estimate Resting Energy Metabolism**).
- Provide 50% of the goal calories the first day, and increase to 100% of goal for the second day if the patient tolerates the initial PN infusion.

2. Determine the percentage of calories to be derived from protein.

- In general, dogs should receive 15% to 25% of calories as protein and cats should receive 25% to 35% of calories as protein.
- The percentage of calories from protein should be at the upper end of the range for protein-depleted patients.
- The percentage of calories from protein

should be in the lower end of the range, or restricted even further, for patients that have conditions that may affect protein tolerance (eg, hepatic or renal failure).

- Protein is supplied using amino acid solutions that can range in concentration from 3% to 10% and provide 4 kcal/g of protein.

3. Determine the percentage of nonprotein calories to be derived from dextrose and the percentage to be derived from lipids.

- For dogs that do not have preexisting evidence of intolerance of carbohydrates (eg, hyperglycemia, insulin resistance) or lipids (eg, hyperlipidemia), nonprotein calories can be evenly divided between dextrose and lipid emulsion.
- Because cats are less able to metabolize carbohydrates, to minimize risk for hyperglycemia fewer of the nonprotein calories should be supplied as dextrose (30% to 40%) and more should be supplied as lipids (70% to 60%) for feline patients that can tolerate lipids.
- Patients showing evidence of intolerance of carbohydrates or lipids should have the PN formulations adjusted accordingly.
- Insulin should be administered as necessary to address hyperglycemia in patients receiving PN—there is growing evidence that even mild hyperglycemia in critically ill patients is associated with a negative outcome.
- Carbohydrates are supplied as dextrose in solutions ranging from 10% to 50% in concentration (**Table 1**).
- Fat is supplied as lipid emulsions ranging from 10% to 30% in concentration (**Table 2**).

4. Decide which electrolytes and micronutrients will be included in the admixture and determine the amounts (Table 3).

- Phosphorus is commonly included in PN admixtures because critically ill patients are at risk for hypophosphatemia secondary to hypercatabolism. Magnesium is sometimes included in the admixture to avoid hypomagnesemia.

Table 1. Osmolarity and Caloric Content of Dextrose Solutions Used to Formulate PN Admixtures

Dextrose Concentration (Wt/volume)	Osmolarity (mOsmol/L)	Caloric Content (kcal/ml)
10%	500	0.17
20%	1000	0.68
50%	2500	1.7

Table 2. Osmolarity and Caloric Content of Lipid Emulsions Used to Formulate PN Admixtures

Lipid Emulsion (Wt/volume)	Osmolarity (mOsmol/L)	Caloric Content (kcal/ml)
10%	260–320	1.1
20%	268–340	2.0
30%	200	3.0

Table 3. Electrolytes and Micronutrients Commonly Added to PN Admixtures

Electrolyte/Micronutrient	Dose
Potassium phosphate	8 mMol/1000 kcal
Magnesium sulfate	0.8 mEq/100 kcal
Zinc chloride	1 µg/kcal
B complex	0.2 ml/100 kcal

- The patient's remaining fluid and electrolyte requirements can be included in the PN admixture. However, although this all-in-one approach may offer convenience in terms of delivery to the patient, it has the significant drawback of hampering the clinician's ability to adjust fluid and electrolyte therapy in response to alterations in the patient's status. Since most patients that receive PN are critically ill, the dynamic nature of their conditions is usually better managed by providing electrolyte and fluid therapy separately from the PN admixture.
- Because most patients receive PN for a relatively brief period, the only micronutrients generally included are B vitamins and zinc.
- Caution should be exercised when supplementing electrolytes and minerals in patients with compromised renal function.

5. Calculate the rate of delivery by adding the amount of all solutions used to prepare the PN admixture. Divide by 24.

- PN should be delivered as a constant-rate infusion 24 hours per day with an infusion pump.
- The infusion set should not be disconnected during delivery, and a new infusion set should be used with each day's bag or bottle of PN.

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- Problems noted in patients receiving PN may include IV catheter problems, septic complications, and metabolic alterations (**Table 4**).
- Careful assessment of the patient before PN is initiated should ensure that the proper route of venous access is selected and that the PN admixture is tailored to the patient, thereby reducing the risk or magnitude of many of these complications.
- Scrupulous catheter care and proper compounding of PN solutions minimize risk for catheter-related and septic complications
- Using a conservative estimate of the patient's energy needs (ie, RER), tailoring the PN admixture to the patient's condition, and careful monitoring will advert or minimize metabolic aberrations.

Course of Treatment

- Patients should receive their goal number of calories as PN until they consistently consume at least 50% of calories voluntarily or by enteral assisted feeding.
- The patient can be weaned from PN by progressively decreasing the rate of administration over the course of several hours once the patient is receiving enteral assisted feeding or has resumed voluntary intake. Alternatively, dextrose can be added to the IV fluids to prevent rebound hypoglycemia in the event that PN must be discontinued abruptly in a patient that is not receiving any other form of nutrition.

Monitoring

- Body temperature, blood analysis, and the catheter site should be monitored for signs of infection.
- In addition to the routine monitoring appropriate to any patient receiving IV fluid therapy, patients on PN should have the following parameters checked to ensure early detection of metabolic complications:
  - Serum glucose concentration at least twice daily
  - Serum electrolytes at least once daily, depending on the circumstances and whether parenteral supplementation is needed
  - Evidence of hyperlipidemia when packed cell volume is measured
  - Complete serum chemistry and complete blood count as indicated but at least once a week

Table 4. Complications in Patients Receiving PN

Catheter-Related
- Premature removal, kinking, or malpositioning of the catheter
- Vascular thrombophlebitis
Septic
- Catheter infection
- Contamination of the PN admixture
Metabolic
- Hyper- or hypoglycemia
- Hyperlipidemia
- Abnormalities of serum electrolytes, including increased or decreased serum concentrations of potassium, phosphorus, magnesium, calcium
- Azotemia
- Hyperammonemia

Relative Cost: $$

Cost Key	
$ = < $100	$$$$ = $500-1000
$$ = $100-250	$$$$$ = > $1000
$$$ = $250-500	

Future Considerations

With greater use of PN in veterinary practice, we should expect to see development and marketing of nutrient solutions tailored to the specific requirements of companion animals, including preparations suitable for peripheral venous infusion.

See Aids & Resources, back page, for references, contacts, and appendices.