Timely Topics in Nutrition

Use of peripheral parenteral nutritional support in dogs and cats

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Metabolic response to illness or injury results in an increased demand for protein and energy, which requires attention to nutritional support. Enteral nutritional support is the preferred method when the gastrointestinal tract is functional. Enteral feeding is preferred to parenteral nutritional support because it preserves the integrity of the gastrointestinal mucosal barrier and function, helps maintain appetite, and is less expensive. When enteral nutritional support is not possible, parenteral nutritional support should be considered (Appendix 1).

Total Parenteral Nutritional Support

Total parenteral nutritional support (total parenteral nutrition [TPN]) has been recommended when the gastrointestinal tract is not functional or in situations in which it is undesirable to use the gastrointestinal tract for nutritional support (eg, severe malassimilation, prolonged ileus, and postoperatively for some surgeries). Solutions used in TPN are usually a combination of glucose, amino acids, and lipids. Because of the high osmolality (> 800 mOsm/L) of TPN solutions, it has been recommended that they be administered via a central vein to prevent thrombosis of a peripheral vein. Disadvantages for the use of TPN include cost, necessity and difficulty of inserting and maintaining a central venous catheter, increased risk of infection, central venous thrombus, and metabolic disturbances. In humans, complications associated with insertion of a catheter in a central vein, such as hematoma or pneumothorax, occur in 3 to 12% of patients. Complications associated with use of a catheter that develop later, including inadvertent catheter removal and central venous thrombosis, are estimated at 9%.

In retrospective studies of TPN in veterinary medicine, rates of 25 to 46% for mechanical complications (eg, catheter or tubing failure) have been reported. Reported rates for metabolic complications have varied from 6 to 78%, depending on the causes included. Transient hyperglycemia was the most common metabolic abnormality in 1 study. Other metabolic complications reported include acid-base abnormalities, electrolyte abnormalities, hypertriglyceridemia, increased urea nitrogen concentration, hypoglycemia, hyperbilirubinemia, increased activity of serum alkaline phosphatase, and glucose intolerance. In a previous study of TPN in 10 dogs, only 2 had patent jugular veins at the end of an IV feeding period of 21 to 32 days, although catheter care, flow rate, and duration of infusion also may have contributed to thromboses. These difficulties and expenses limit the use of TPN in veterinary practices.

Peripheral Parenteral Nutritional Support

Peripheral parenteral administration of nutritional support (peripheral parenteral nutrition [PPN]) is the IV provision of nutritional support by use of a peripheral vein. A considerable amount of research on PPN was conducted in human medicine in the 1970s. Interest declined in the 1980s when TPN became more popular. Technical improvements have been made in catheters and nutritional solutions and estimations of energy requirements have been reduced; thus, there has been renewed interest in PPN for use in humans.

Solutions used in PPN are lower in osmolality than those used for TPN; therefore, they can be administered via a cephalic or saphenous vein. The solutions also are lower in energy and protein and should not be used in debilitated animals needing full nutritional support. Patients that are good candidates for PPN include non-debilitated animals that will likely need IV-administered support for < 7 days, those in which a catheter cannot be inserted in a jugular vein, and those that need adjunct nutrients because their nutritional needs cannot be completely met with enteral feeding. Another indication would be an animal that would benefit from short-term parenteral nutritional support prior to anesthesia for placement of a gastrostomy or jejunostomy tube.

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Objectives for the use of PPN include sparing protein from catabolism by providing an energy source such as glucose or lipids as well as providing amino acids for protein synthesis. In fasting human patients, infusion of 5% glucose solution is used to decrease nitrogen loss, because the solution partially fulfills energy requirements and reduces the amount of glucose that must be produced by catabolism of amino acids for gluconeogenesis. It has been proposed that administration of isotonic glucose solutions are beneficial for sparing protein; conversely, it has been suggested that isotonic glucose solutions have little protein-sparing effect. One study involving the use of 3 healthy dogs revealed a minor amount of protein sparing from infusion of 5% glucose solution, but additional work should be conducted to confirm these findings.

Other PPN solutions that have been used for protein sparing in humans include amino acid solutions used alone or supplemented with glucose, lipid, or both. Nitrogen balance can be used to assess efficacy of nutritional support. Amino acid solutions result in a more positive (or less negative) nitrogen balance than use of glucose solutions alone. Adding glucose to amino acid solutions reportedly can improve nitrogen balance. Conversely, administration of amino acid solutions without glucose resulted in a more positive nitrogen balance than amino acid solutions with glucose, and nitrogen balance was not affected by the addition of glucose to an amino acid solution. Proposed negative effects of the administration of glucose solution were that an increase in insulin secretion resulted in decreased endogenous lipolysis and ketosis. Decreased use of fat and increased use of amino acids for energy would result in a more negative nitrogen balance. In septic patients, insulin resistance may exacerbate these effects. Other authors have suggested that there is substantial lipolysis during infusion of a 5% glucose solution despite increased insulin concentrations. More recently, it was suggested that improved nitrogen balance observed with administration of an amino acid solution without glucose may have been an artefact resulting from differing nitrogen content of the 2 formulas used in that study. It also is worth mentioning that these studies were performed in humans, and nondiabetic dogs become ketotic more slowly than humans. Although a 5% amino acid solution used alone can improve nitrogen balance in dogs, ideally when amino acids are used, an energy source such as glucose should be used to provide calories. This allows the amino acids to be used for support of protein synthesis rather than being used less efficaciously via catabolic pathways to provide energy.

Lipids have been used as an energy source in protein-sparing solutions. Fat is considered to be the preferred energy source in ill or injured, fasting human patients. Lipid solutions manufactured for IV administration are often made from soybean oil plus glycerol and provide more calories than glucose when given as an iso-osmotic solution. They also help prevent deficiencies of essential fatty acids in humans. Deficiencies of fatty acids have been detected in humans after 10 days of fat-free parenteral nutritional support. Olive oil, which contains monosaturated fatty acids, is added to soybean oil in some of the newer products. Diets high in monosaturated fatty acids will lower plasma triacylglycerol concentrations and, therefore, may decrease the risk of hypertriglyceridemia in patients receiving lipid-containing parenteral nutritional support.

In several studies, investigators have documented that lipid given IV with amino acid solutions was comparable in protein-sparing effect to glucose given with amino acid solutions. In 2 studies, it was concluded that the major protein-sparing effect of lipid emulsions was attributable to the glycerol fraction of the solutions.

Lipid solutions manufactured for IV administration should be used with care in patients with high serum triglyceride concentrations, impaired lipid clearance, impaired hepatic function, or pancreatitis. Hypertriglyceridemia can inhibit function of the reticuloendothelial system. Intravenous administration of lipid solutions containing soybean products can result in hypertriglyceridemia leading to increased neutrophil degranulation and release of interleukin-6 in patients given endotoxin IV. However, lipid emulsions containing omega-3 fatty acids have a protective effect against the effects of endotoxemia and lactic acidosis.

Three-in-one solutions (glucose, amino acids, and lipid) have been used for PPN as well as TPN. These may be adjusted to suit an animal’s specific needs and are probably the ideal solutions to use. In some areas, human hospitals or pharmacies may be willing to compound parenteral nutritional solutions, provided the formulation is supplied by a veterinarian. Excellent practical protocols for calculating and administering three-in-one solutions to animals have been published. Readers are urged to use these references to obtain the details of formulation. Prepackaged three-in-one PPN products for use in humans also may provide a simple and practical means for providing PPN, although they lack the flexibility of a specific formulation for each animal.

Peripheral Venous Thrombophlebitis
Peripheral venous thrombophlebitis (PVT) is a potential complication in administration of PPN that can result in inflammation of the limb, venous thrombosis, extravasation of the solution, and failure of the IV injection tubing. In human patients, PVT was the primary reason that PPN was not used more often. The initiating factors in PVT may be damage to the venous wall and endothelium caused by inserting the catheter and movement of the catheter within the vein. Fibrin, WBC, RBC, and platelets adhere to the catheter within the first few hours after initiation of an IV infusion. Endothelial damage leads to venoconstriction, which increases endothelial irritation and decreases venous dilution of the infusion solution. Local release of inflammatory and vasoactive mediators escalates the inflammatory response, causes platelet aggregation, and then can result in thrombosis (Fig 1). Factors exacerbating PVT that can be influenced by clinical management can be divided into 2 general categories: catheter factors and infusion solution factors. Small-diameter catheters and silicone catheters, compared to those made of polyurethane or fluoride-containing compounds, are less likely to cause PVT.
Site of catheter placement influences the incidence of PVT. When the catheter tip is positioned near a joint, movement of the tip may increase endothelial damage. The greater the amount of time that a catheter remains in a vein, the greater the likelihood of PVT. Studies in human patients revealed a decreased incidence of PVT when the catheter was replaced every 24 hours and the administration of the infusion solution was limited to 12 hours instead of 24 hours. Infusion solutions with osmolality > 600 mOsm/L are more likely to cause PVT than solutions with osmolality < 600 mOsm/L, although the osmolality rate (osmolality of solution × infusion rate) may be more important than osmolality alone. The use of lipids as an energy source allows lower osmolality for the amount of calories provided, and lipid solutions appear to have a protective effect on the venous endothelial wall.

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When amino acid solutions are infused, 70% of sites develop PVT after an average of 48.9 hours, compared to an incidence of 44% after 88.6 hours for nonnitrogen containing solutions, possibly because of the acidity of the solution. Buffering solutions to maintain the pH between 7.2 and 7.4 reduces the incidence of PVT.

Other recommendations for preventing PVT in human patients have included the use of in-line filters to screen particulate matter in solutions, addition of a low dose of heparin (0.5 to 1 U/ml) to the infusion solution to minimize fibrin clots around the catheter tip, addition of a low dose of hydrocortisone (5 mg/L) to the infusion solution to decrease venous inflammation, application of transdermal glycerol trinitrate over the anticipated site of the catheter tip to induce venodilation and stimulate prostacyclin synthesis, and use of topical nonsteroidal anti-inflammatory ointments over the catheter site.

Conclusions
Use of PPN by veterinarians is increasing. Well-nourished animals undergoing elective surgery or diagnostic procedures can easily tolerate several days without food and should not be subjected to the risk and expense associated with parenteral administration of nutrients. Animals with severe malnutrition or debilitating disease that cannot be given enteral nutrition should, ideally, be given TPN. Animals of marginal nutritional status that must undergo periods without food also are candidates for PPN. Clinicians may use PPN to supplement inadequate enteral intake until full enteral support is achieved.

Solutions and protocols for use in PPN would depend on an animal’s disease as well as the therapeutic goals for each animal. Other factors that should be considered include availability of solutions, ease of preparation and administration, and cost. Additional studies of the metabolism of ill or injured animals will help clinicians to tailor the solutions that they recommend, and studies of methods to prevent PVT in animals may provide means of providing TPN via a peripheral vein.

Appendix 1
Comparison of methods of nutritional support

<table>
<thead>
<tr>
<th>Factor</th>
<th>Enteral feeding</th>
<th>TPN</th>
<th>PPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indications</td>
<td>Preferred whenever the gastrointestinal tract is functional</td>
<td>Severe malnutrition; debilitating disease</td>
<td>Moderate malnutrition; adjunct to enteral nutrition</td>
</tr>
<tr>
<td>Nutritional support</td>
<td>Complete support</td>
<td>Complete support</td>
<td>Protein-sparing; potentially complete support provided</td>
</tr>
<tr>
<td>Effect on gastrointestinal tract function</td>
<td>Preserves mucosal barrier of gastrointestinal tract</td>
<td>Associated with increased permeability of gastrointestinal tract</td>
<td>Associated with increased permeability of gastrointestinal tract (when used alone)</td>
</tr>
<tr>
<td>Comparative cost</td>
<td>Least expense</td>
<td>Most expense</td>
<td>Moderate expense</td>
</tr>
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TPN = Total parenteral nutrition. PPN = Peripheral parenteral nutrition.
Appendix 2
Factors in the development of peripheral venous thrombosis and techniques for minimizing their effects

<table>
<thead>
<tr>
<th>Factor</th>
<th>Technique for minimizing effect</th>
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<tbody>
<tr>
<td>Catheter size</td>
<td>Use smallest gauge catheter possible</td>
</tr>
<tr>
<td>Catheter material</td>
<td>Polyurethane</td>
</tr>
<tr>
<td>Catheter infection</td>
<td>Proper care and bandaging of catheter</td>
</tr>
<tr>
<td>Duration of infusion</td>
<td>Short-term infusion (&lt; 24 hours’ duration), rotate catheter sites</td>
</tr>
<tr>
<td>Nature of infusion</td>
<td>Solutions with lipids, minimal osmolality of solutions</td>
</tr>
<tr>
<td>Trauma during venipuncture</td>
<td>Careful insertion, use of a small catheter</td>
</tr>
</tbody>
</table>


References

