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Retrospective Study

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Clinical experience with a lipid-free, ready-made parenteral nutrition solution in dogs: 70 cases (2006–2012)

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Abstract

Objective – To review the clinical use of a lipid-free, ready-made amino acid and glucose parenteral nutrition (PN) solution in dogs.
Design – Retrospective study of dogs from 2006 to 2012 that received this form of PN.
Setting – University veterinary teaching hospital.
Animals – Seventy dogs presented to the hospital for treatment of various diseases in which PN was used as part of patient management. Dogs were administered PN at the discretion of the primary clinician.
Intervention – A lipid-free, ready-made solution containing amino acid (59 g/L) and dextrose (100 g/L) was administered intravenously as a constant rate infusion to provide nutritional support.
Measurements and Main Results – PN was provided for a median of 2.2 days (range 0.5–9.5 days) in the 70 dogs, totaling 168 days of PN. The PN provided a median of 5.5 g/100 kcal of protein (range 1–9.5 g/100 kcal) and a median of 2.2 mg/kg of bodyweight per minute (range 0.8–5.2 mg/kg/min) of glucose, which reflected a median of 57% of the resting energy requirement (range 9–100%). Metabolic complications developed in 43 of 67 dogs where these data were recorded, but the development of hyperkalemia was the only complication associated with a poor outcome (eg, death or euthanasia). Mechanical complications were seen in 28 dogs, and all but one of these occurred when PN was delivered through peripheral catheters. Septic complications were confirmed in 5 dogs.
Conclusions – This form of PN is suitable for clinical use and can provide both protein and calories to ill dogs. It was, however, associated with a high rate of complications and requires careful patient monitoring.

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Introduction

The use of parenteral nutrition (PN) in veterinary medicine has increased in recent years.[1–6] However, routine use of PN in general veterinary practice is hindered by the relatively high cost of this form of nutrition, the requirement for time and expertise in compounding the PN solution and a perceived high rate of complications associated with its use. Total parenteral nutrition (TPN) was previously defined as the intravenous provision of all of a patient's protein, calorie, and micronutrient requirements, whereas partial parenteral nutrition (PPN) was defined as the provision of only a

Abbreviations

IQ	interquartile
PN	parenteral nutrition
TPN	total parenteral nutrition
PPN	partial parenteral nutrition
RER	resting energy requirement

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part of these requirements (typically 40–70% of the energy requirement).[7] In the latter form, enteral nutrition may be voluntarily consumed or provided by a feeding tube to supplement the PN. More recently, there has been a shift away from describing PN in terms of meeting energy and nutrient requirements as they remain largely unknown in animals. Current recommendations categorize PN by the mode of delivery, such that PN delivered into a central vein is described as central PN and PN delivered into a peripheral vein is described as peripheral PN.[6]

All 3 components of PN (lipids, amino acids, and glucose) provide energy, and the lipid solution is the most energy dense component.[8] The iso-osmolar lipid component also serves an important role in reducing the tonicity of the final PN solution. Commercially available ready-made PN solutions include formulations with and without lipids. Despite the benefits of including lipids in PN solutions, they may have detrimental effects on immune function and hemodynamics, in addition to pro-inflammatory and pro-oxidant effects. PN-containing lipids may result in an increased risk for hyperlipidemia, lipid embolization, and microbial contamination of the solution.[9–21] The principal type of lipid used for PN in most countries is derived from soybean oil (a long-chain triglyceride-containing linoleic acid), and its effect on the inflammatory system via increased production of the omega-6 family of inflammatory mediators has been investigated.[15] In vivo studies in people have shown an exaggerated inflammatory response to endotoxin following a long-chain triglyceride infusion.[18] Hypertriglyceridemia developed in up to 46% of dogs and cats receiving PN in an early description of PN use in animals.[1] In a more recent report, although 62% of dogs were hypertriglyceridemic during PN administration, only 1 out of 14 dogs developed this problem without being hypertriglyceridemic before PN administration.[6] Lipid emulsions may also support bacterial and fungal growth because of their isotonicity and neutral pH, although compounding standards have greatly reduced the risk for contamination.[9–12]

A study evaluating the effects of lipid-containing parenteral infusions in human trauma victims found significantly reduced duration of hospitalization, duration of intensive care, and days of mechanical ventilation in patients receiving lipid-free PN.[22] However, the group receiving lipid-containing PN also received greater numbers of calories than the lipid-free group.[22] Experimental studies in dogs receiving lipid infusions demonstrated reduced ventricular function and decreased systemic vascular resistance.[21]

Toxicity caused by leaching of lipid-soluble phthalates (used as plasticizers in polyvinyl-chloride-based delivery systems) is another concern in long-term human PN.[23] Although, other components in PN solutions may also contribute to leaching of phthalates from polyvinyl-chloride materials, the lipid component has been recently implicated as the principal component mediating toxicity.[24] For this reason, bags composed of a material other than polyvinyl-chloride are being advocated for use with PN.

The provision of amino acid and glucose solutions have been shown to improve nitrogen balance in healthy dogs undergoing starvation.[25] Although several commercially available amino acid and glucose solutions exist, there are no published papers of their clinical use in dogs or cats.[26] The purpose of this retrospective study was to evaluate the utility of a ready-made, lipid-free PN solution[a] for use in a clinical setting. In particular, we sought to describe certain aspects related to the use of this form of PN such as the ease of implementation, ability to provide calories and protein to hospitalized dogs, and the rate of complications.

Materials and Methods

Patient selection

The medical records of all dogs receiving PN at the Queen Mother Hospital for Animals of the Royal Veterinary College, University of London, between November 2006 and February 2012 were reviewed. These patients were identified from the invoicing records where the terms "TPN," "PPN," or "Vamin 9 Glucose" were recorded. Patients were excluded from the study if their medical records were incomplete, if they received compounded PN rather than the product under investigation or when the solution was administered for <12 hours. Signed consent for hospitalization was obtained from the owners of all dogs prior to admittance to hospital.

Procedures

The PN solution[a] investigated in the present report is a ready-made, medical grade, lipid-free amino acid and glucose solution. It has a shelf life of 12 months when stored between 0 and 25°C. The solution contains 9.4 g nitrogen (5.9% or 59 g/L of amino acid solution) including 18 amino acids that are detailed in Table 1. The PN solution also contains 100 g/L of glucose and electrolytes including calcium (2.5 mmol/L [10 mg/dL]), magnesium (1.5 mmol/L [3.6 mg/dL]), potassium (20 mmol/L [20 mEq/L]), sodium (50 mmol/L [50 mEq/L]), and chloride (50 mmol/L [50 mEq/L]). The solution has a pH of 5.2, an osmolality of 1,350 mOsmol/kg, and provides 650 kcal/L. The calorie:nitrogen ratio for this product is 61:1 and the nonprotein calorie:nitrogen ratio is 36.2:1.

Table 1: Amino acid content and concentration of a commercial ready-made, lipid-free parenteral nutrition solution

Amino acid	Concentration (g/L)
Alanine	3.0
Arginine	3.3
Aspartic acid	4.1
Cysteine/cystine	1.4
Glutamic acid	9.0
Glycine	2.1
Histidine	2.4
Isoleucine	3.9
Leucine	5.3
Lysine	3.9
Methionine	1.9
Phenylalanine	5.5
Proline	8.1
Serine	7.5
Threonine	3.0
Tryptophan	1.0
Tyrosine	0.5
Valine	4.3

The PN solution was administered via a peripheral (cephalic, saphenous, or femoral) catheter solely used for PN administration or via a dedicated port of a multiple lumen central (ie, jugular) catheter. Typically, a fluorinated ethylene propylene polymer peripheral catheter[b] (eg, 20–Ga and 32 mm long or 22–Ga and 25 mm long) placed in the cephalic or saphenous (medial or lateral) vein or a polyurethane long-term catheter[c] (eg, 16–Ga and 15 cm long) placed in the medial saphenous vein was used for peripheral administration. For central PN administration, a triple-lumen long-term polyurethane catheter[c] (eg, 7–Fr and 15 cm long or 4–Fr and 13 cm long) placed in the external jugular vein was used. All catheters were placed with strict adherence to aseptic technique. The PN was never disconnected from the patient during the infusion (eg, the dogs were walked with the PN solution attached) and it was administered continuously via an infusion pump. The peripheral catheters were replaced every 3 days or sooner if complications arose. All catheters were checked daily (under aseptic conditions) or sooner if catheter-related complications were suspected.

Nutritional support utilizing this PN solution was implemented by various services in the hospital with or without advice from the Nutritional Support Service. A standardized worksheet was provided that enabled calculations of energy and protein requirements, proportion of the energy requirement to be provided by the PN solution, and the maximal allowable rate of glucose infusion. It was recommended that patients on this form of PN be monitored by at least twice-daily physical examinations (including measurement of rectal temperature and bodyweight), daily blood tests to monitor packed cell volume, total plasma protein, serum biochemistry, and electrolytes, and that a complete blood count and blood or catheter tip culture be performed if there was a clinical suspicion of a local or systemic infection.

The energy requirement was calculated to be the patient's resting energy requirement (RER) by the formula: RER in kcal per day $= 70 \times$ (bodyweight in kg)$^{0.75}$, or for animals weighing between 2 and 30 kg by the formula: RER in kcal per day $= 30 \times$ (bodyweight in kg) $+ 70$. Illness factor multipliers were not used and RER was calculated to the current bodyweight. Guidelines were provided on the worksheet for protein provision depending on the clinical indication: a standard protein allocation was 4 g/100 kcal, an increased protein allocation was 6 g/100 kcal, and a reduced allocation was 2–3 g/100 kcal. The rate of glucose infusion was recommended to be maintained below 4 mg of glucose per kilogram of bodyweight per minute. For example, a 20 kg dog would have a calculated RER of 662 kcal/d. If a standard protein provision (ie, 4 g/100 kcal) was desired, a total daily protein provision target of 26.5 g would be set for such a dog. To achieve this, the PN infusion rate would be set to 19 mL/h (1 mL/kg/h) which would provide 45% of the RER for such a dog and would deliver glucose at an infusion rate of 1.6 mg/kg/min. If the same dog required a reduced protein provision (eg, 2.5 g/100 kcal) because of its underlying disease (eg, chronic kidney disease), 16.6 g/d of protein would be necessary. This would require a PN infusion rate of 12 mL/h (0.6 mL/kg/h) and would meet only 28% of this dog's RER with a glucose infusion rate of 1 mg/kg/min. Finally, if an increased protein provision (eg, 6 g/100 kcal) was desired, 39.7 g/d of protein would be necessary, requiring a PN infusion rate of 28 mL/h (1.4 mL/kg/h) and providing 66% of this dog's RER, with a glucose infusion rate of 2.3 mg/kg/min.

The PN infusion rate was administered at 50% of the maximum calculated rate for the first 24 hours to monitor for the development of any metabolic complications. If no complications arose after 24 hours, the rate was increased to the maximum rate. The subsequent infusion rate was then adjusted accordingly if complications developed (eg, PN rate was reduced by 50% if hyperglycemia developed or potassium supplementation was discontinued if hyperkalemia developed). Supplemental enteral nutrition was voluntarily consumed or provided via a feeding tube in most animals.

Data collected from the medical records included the patient's signalment, bodyweight, body condition score, presenting complaint, final diagnosis, reason for instituting PN, time to initiation of PN from admission to hospital, maximum protein provision (g/100 kcal), maximum glucose infusion rate (mg/kg/min), initial percentage of RER provided, maximum percentage of RER

provided, route of administration (peripheral versus central catheter), duration of PN therapy, type of supplementary enteral nutrition, estimated percentage of RER provided by enteral nutrition, type and rate of concurrent intravenous fluid therapy, potassium supplementation in fluid therapy, duration of hospitalization, and outcome (discharge from hospital, death, or euthanasia).

The clinical records and laboratory data were evaluated to determine the type and frequency of complications. Complications associated with PN administration were classified as mechanical, metabolic, or septic. Mechanical complications included thrombophlebitis, catheter occlusions, disconnected or damaged fluid administration lines, or any other technical problems associated with the delivery of PN. Septic complications were characterized by a clinical suspicion of sepsis and confirmed via a positive catheter tip or blood culture result. A clinical suspicion of sepsis was raised if the patient developed pyrexia or a left-shifted neutrophilia and a reason for this was not obvious from the underlying disease. Metabolic complications were defined as increases or decreases in the concentrations of blood glucose (reference interval, 4.2–6.6 mmol/L [76–119 mg/dL]), potassium (reference interval, 3.6–4.6 mmol/L [3.6–4.6 mEq/L]), urea (reference interval, 3–10 mmol/L [8.4–28 mg/dL]), creatinine (reference interval, 50–140 μmol/L [0.6–1.6 mg/dL]), phosphorus (reference interval, 0.8–1.8 mmol/L [2.5–5.6 mg/dL]), or bilirubin (reference interval, 0–2.4 μmol/L [0–0.14 mg/dL]) after PN administration, in which the value was within the reference interval prior to PN administration. Patients were excluded from analysis for calculating rates of metabolic complications if follow-up blood testing was not performed.

Statistical methods

All statistical tests were performed with a commercial statistical software package.[d] Data are described as median (range) for continuous data after assessment of nonnormality of distribution, and as proportions for categorical data. Laboratory measurements are described as median with interquartile (IQ) ranges. Mann-Whitney *U*-tests were used to test the statistical significance of differences in median values of continuous variables among categories of categorical variables. Where appropriate, Pearson chi-square or Fisher's exact tests were used to assess associations among categorical variables. Statistical significance was set at $P < 0.05$.

Results

Patient demographics

During the study period 82 dogs received this form of PN. Patients were excluded due to missing or incomplete records ($n = 10$) or when the PN was administered for less than 12 hours ($n = 2$). This report includes the information from 70 dogs that summated to 167.8 days of PN therapy.

Table 2: Reason for administering a ready-made, lipid-free parenteral nutrition solution in 70 dogs

Reason	Number of dogs	Percentage of dogs
Anorexia/inappetence	33	47
Vomiting	14	20
Vomiting + inappetence	13	19
Regurgitation	5	7
Trismus/dysphagia	2	3
Mechanical ventilation	2	3
Obtundation	1	1
Total	70	100

The median age of the dogs in this report was 4.2 years (0.2–15 years). Thirty-four different dog breeds were represented, with Labrador retrievers ($n = 10$) being the most commonly represented. The population included 31% female neutered, 29% male neutered, 23% male entire, and 17% female entire dogs. Thirty-one percent of dogs weighed <10 kg, 23% weighed between 10 and 20 kg, and 46% weighed >20 kg. The median weight of the dogs in this report was 15.7 kg (1.6–58 kg). Body condition score was only available in 16 dogs and ranged from 2/9 to 7/9.

PN was most commonly administered because of a combination of anorexia or inappetence ($n = 33$) or vomiting ($n = 14$), as summarized in Table 2. A variety of underlying diseases were identified, with pancreatitis ($n = 9$) and immune-mediated hemolytic anemia ($n = 8$) the most common. Based on a body system categorization, 23 dogs had gastrointestinal disorders (including gastroenteritis, peritonitis, intussusceptions, and esophageal disorders), 10 dogs had hematologic disorders (including immune-mediated hemolytic anemia), 9 had pancreatic disease (ie, pancreatitis), 6 had neurologic diseases (including tetanus), 6 had neoplastic diseases, 5 had kidney disease (including acute kidney injury), 4 had hepatic disease, and the remaining 7 dogs were afflicted by miscellaneous disorders (including trauma).

PN delivery details

The median duration from admittance to the hospital to initiation of PN was 3 days (0.25–26 days). Additional IV fluid therapy was provided in 61 dogs, including isotonic crystalloids alone in 47 dogs, artificial colloids alone in 5 dogs, and a combination in 9 dogs. PN was provided via a peripheral catheter in 66% of dogs (46/70) whereas in the remaining dogs it was

Table 3: Details of metabolic complications observed following administration of a ready-made, lipid-free parenteral nutrition solution to 67 dogs

Metabolic complication	Number of dogs affected
Hyperglycemia	19
Hyperkalemia	12
Azotemia	4
Hyperphosphatemia	1
Hypokalemia	2
Hyperglycemia and hyperkalemia	3
Hyperglycemia and azotemia	1
Hyperglycemia, hyperkalemia, and azotemia	1
Total	43

Table 4: Details of mechanical complications observed following administration of a ready-made, lipid-free parenteral nutrition solution to 70 dogs

Mechanical complication	Numbers of dogs affected
Catheter dislodgement	24
Leaking fluid from catheter site	2
Damaged catheter or fluid administration set	1
Thrombosed vein	1
Total	28

delivered via a central (ie, jugular) catheter. Additional information with regards to the catheter length and specific site used was not available. The median duration of PN administration was 2.2 days (0.5–9.5 days). The median proportion of RER provided by the PN was 57% (9–100%). In 61 dogs (87%), greater than 40% of the calculated RER was provided by the PN. The median protein provision was 5.5 g/100 kcal (1–9.5 g/100 kcal). The median rate of glucose infusion was 2.2 mg of glucose/kg of bodyweight/min (0.8–5.2 mg/kg/min). Supplemental enteral nutrition was consumed by 57 dogs (81%), including an estimated consumption of less than 25% of the RER in 43 dogs, between 25% and 50% of the RER in 7 dogs, between 50% and 75% of RER in 3 dogs, and greater than 75% of the RER in 4 dogs.

Complications

The PN complications observed were categorized as metabolic, mechanical, or septic complications. Metabolic complications were observed in 43 dogs from a total of 67 dogs where this information was available (Table 3). This included 5 dogs where more than one metabolic complication developed at the same time.

Hyperglycemia classified as a metabolic complication was noted in 24 dogs (either as a sole complication or in combination with other metabolic complications). The median of the highest post-PN serum blood glucose concentration in those dogs that developed hyperglycemia as a metabolic complication was 7.5 mmol/L (135 mg/dL) (IQ range, 6.6–25 mmol/L [119–450 mg/dL]). The rate of glucose infusion provided by the PN in those dogs that developed hyperglycemia as a metabolic complication was not different to those that did not develop this complication ($P = 0.38$). No dogs developed hypoglycemia as a metabolic complication.

Hyperkalemia, was noted in 16 dogs either as a sole complication or in combination with another metabolic complication. The median of the highest post-PN serum potassium concentration in those dogs that developed hyperkalemia was 4.9 mmol/L (4.9 mEq/L; IQ range, 4.7–7.2 mmol/L [4.7–7.2 mEq/L]). Potassium supplementation was provided in the intravenous fluids of 53% of dogs overall and in 63% of dogs that developed hyperkalemia; however, there was no significant relationship between potassium supplementation and the development of hyperkalemia ($P = 0.38$). Two dogs developed hypokalemia.

Azotemia as a metabolic complication (ie, pre-PN blood urea and creatinine concentrations within the reference interval, but either or both post-PN values above the reference interval) was noted in 6 dogs either as a sole complication or in combination with another metabolic complication. The amount of protein provided by the PN in those dogs that developed azotemia as a metabolic complication was not different from the rate of protein provision overall ($P = 0.31$). Hyperphosphatemia was noted in 1 dog, and no dog developed hypophosphatemia. No dogs developed hyperbilirubinemia. The amount of calories provided (percentage of RER) was not significantly associated with the development of hyperglycemia ($P = 0.65$), hyperkalemia ($P = 0.39$), azotemia ($P = 0.45$), or hyperphosphatemia ($P = 0.47$).

Mechanical complications were noted in 28 dogs (Table 4). All but one of these complications was associated with the use of peripheral catheters; the association between the use of peripheral catheters and the development of mechanical complications was significant ($P < 0.01$). Septic complications were suspected in 24 dogs and confirmed (via positive catheter tip culture) in 5 dogs (Table 5). There was no association found between the development of septic complications and the duration of PN ($P = 0.07$), type of catheter (central vs. peripheral; $P = 0.52$), or amount of calories (% of RER) provided ($P = 0.18$). The overall complication rate (ie, total number of metabolic complications, mechanical complications, and confirmed septic complications) for this type of PN was 0.49 complications/day of PN.

Table 5: Details of suspected septic complications observed following administration of a ready-made, lipid-free parenteral nutrition solution to 70 dogs

Suspected septic complication	Numbers of dogs affected
Unexplained pyrexia	15
Left-shifted neutrophilia	3
Positive catheter culture	2
Pyrexia and positive catheter culture	2
Neutrophilia and pyrexia	1
Pyrexia, neutrophilia, and positive catheter culture	1
Total (positive catheter culture)	5

Outcome

Thirty-two dogs (46%) were discharged from the hospital, whereas 11 died and 27 were euthanized. The median duration of hospitalization overall was 7.0 days (2–31 days). The median duration of hospitalization of the survivors was 8 days (2–31 days) whereas that of the nonsurvivors was 6 days (2–16 days), although this difference was not statistically significant ($P = 0.07$). The development of any PN-related complications (mechanical, metabolic, or septic) was not associated with the duration of hospitalization ($P = 0.50$).

Neither the development of hyperglycemia ($P = 0.60$) nor the development of azotemia ($P = 0.21$) was associated with outcome, but the development of hyperkalemia was associated with a poor outcome (death or euthanasia) ($P = 0.014$). The provision of potassium supplementation in IV fluids was also associated with a poor outcome ($P = 0.018$). The development of metabolic complications overall was not associated with outcome ($P = 0.19$). The development of mechanical ($P = 0.12$) or septic ($P = 0.89$) complications was also not associated with outcome. The provision of supplemental enteral nutrition was not associated with outcome ($P = 0.12$).

Discussion

One apparent advantage of the ready-made PN solution was its relative convenience when compared to compounded PN. Use of a ready-made PN solution allowed a more rapid initiation of nutritional support in our institution than previously, as it avoided delays involved in formulating and compounding PN solutions. The worksheets also enabled administration of PN by clinicians of other services (eg, Emergency and Critical Care, Internal Medicine) when a member of the Nutrition Support Service was not available. The median duration from hospitalization to initiation of PN in this report was 3 days, which was similar to previous reports from other institutions.[2–4] The ready-made solution was also approximately a third of the cost of compounded PN in our hospital, which was seen as an additional advantage.

Authors have suggested that a reasonable target for energy provision with PN should constitute approximately 40–70% of RER.[7,8] This hypocaloric approach could be employed in the short term (ie, 3–5 days) especially if additional calories are provided by the enteral route. This somewhat arbitrary energy target provision of 40–70% of RER was met in the majority of dogs by use of this ready-made solution (87% of dogs received >40% of RER by PN alone). In addition, 81% of dogs in this report received additional energy via supplemental enteral nutrition. The PN in our report was provided for a median 2.2 days (52 hours), compared with a median of 3 days in a previous report detailing the use of PPN in dogs.[3] PN can be theoretically administered for longer periods, especially when a greater proportion of energy and nutrient requirements are provided. Previous veterinary reports detailing PN use in dogs and cats cite a similarly short duration of PN administration (ranging from 3.5 to 4.8 days).[1,2,4,5]

The PN protocols employed in the current study included nutritional targets of energy provision as a percentage of RER and grams of protein in relation to energy provision. Previous guidelines in people included target nonprotein calorie:nitrogen ratios for PN that would be appropriate for patients with varying degrees of metabolic stress.[27,28] For example, a patient with minimal metabolic stress would have been managed with a PN formulation with a nonprotein calorie:nitrogen ratio of 150:1, whereas a critically ill patient would be managed with calorie:nitrogen ratios of 100:1 to 120:1.[27,28] The current human guidelines for nutritional support in critically ill patients state that determination of protein requirements in the critical care setting is difficult to measure, and so they may be derived from simplistic equations such as 1.2–2.0 g/kg/d or nonprotein calorie:nitrogen ratio of 70:1–100:1.[29] The PN solution in the current study has a nonprotein calorie:nitrogen ratio of 36:1 but the optimal ratio has not been determined for dogs, healthy or otherwise. It is interesting to note that the current nutritional support guidelines for critically ill children make no specific recommendations for partitioning of major substrates (ie, protein, carbohydrates, and lipids) because of insufficient data to make evidence-based recommendations for macronutrient intake.[30]

Because of concerns that lipids may cause immune suppression and support microbial growth in PN solutions, the risk of septic complications would be expected to be higher when lipid-containing PN solutions are used. Previous veterinary reports of lipid-containing PN solutions have reported a septic complication rate (confirmed via catheter tip or blood culture) of up to 8%

of cases.[1–6] Five dogs (7%) in this study had confirmed septic complications. This suggests that the provision of a lipid-free PN solution may not necessarily be associated with a reduced rate of septic complications (although a prospective evaluation of both forms of PN would be required to answer this question). This is in agreement with a recent human report that demonstrated no increased risk for infectious morbidity in people receiving lipid emulsions.[31]

Pancreatitis was the most common underlying disease in this report and in other recent studies on PN in dogs.[2–4,6] Established guidelines in human medicine dictate reduced lipid provisions when hypertriglyceridemia and pancreatitis are present.[32] Considering PN is frequently used to support patients with pancreatitis, it is conceivable that this lipid-free PN solution could be used in patients that develop hypertriglyceridemia. However, for this recommendation to be made, measurement of serum triglyceride concentrations prior to initiation and following administration of this form of PN would be necessary to confirm that this metabolic complication does not occur.

The overall complication rate with this type of PN was 0.49 complications per day of PN. This compares less favorably to individually compounded PPN that was reported to have a complication rate of 0.17 per day of PN,[3] but is not dissimilar to reports describing TPN use in dogs (0.53 per day).[2] Differences in the rates of complications may not be simply a consequence of the type of PN provided, as several factors, including variability in the reporting of complications, may be involved. More meaningful comparison of complication rates would necessitate standardized protocols for the manner in which complications are defined, monitored and recorded.

Consistent with previous reports, hyperglycemia was the most common metabolic complication recorded with this form of PN, with 35% (24/67) of dogs affected. However, the median of the highest blood glucose concentration recorded in these dogs was only mildly increased (7.5 mmol/L [135 mg/dL]). More importantly, the development of hyperglycemia was not associated with a poor outcome. This is in contrast to a previous report on PN in cats, where the development of hyperglycemia was associated with a poor prognosis.[4] Similarly, a study of hyperglycemia in critically ill dogs revealed a negative impact of this factor on hospitalization and outcome.[33] Although it is possible that our study was underpowered to detect a link between the hyperglycemia and a poor outcome, several other larger studies showed similar outcome measures.[2,3,6]

Although patients with hyperkalemia only exhibited mild increases in serum potassium concentration (the median of highest recorded value was 4.9 mmol/L [4.9 mEq/L]), the development of hyperkalemia was associated with a poor outcome. While the provision of supplemental potassium in the crystalloid fluid therapy did not increase the likelihood of hyperkalemia, this supplementation was negatively associated with outcome. The retrospective nature of this study and the relatively small population size limit our ability to determine whether hyperkalemia was an independent risk factor for a poor outcome or simply a surrogate marker for more severe metabolic derangement. Regardless, this information indicates that patients receiving this form of PN should be closely monitored for the development of hyperkalemia. If hyperkalemia develops, steps should be taken to rapidly correct potassium levels.

In this retrospective study, poor appetite was cited as the main reason for instituting PN. However, it should be noted that poor appetite alone is not an indication for the administration of PN. In most clinical circumstances, the provision of enteral nutrition (eg, via a feeding tube) is preferred to PN.[7,8] In the majority of dogs in this study, PN was used to supplement enteral caloric intake that was deemed inadequate to support the patient's needs, which is a recognized indication for PN.[7,8]

In a previously published report on PPN in dogs and cats, 21 of 80 dogs (26%) developed mechanical complications.[3] This complication rate is less than that found in our study (28 of 70 dogs, 40%). It should be noted that in the previous study the PPN was administered via a central venous catheter in 51% of the cases, whereas in our study the number of jugular venous catheters used was much lower (34%). Because all but one of the mechanical complications in our study occurred when PN was administered via peripheral venous catheters, it is possible that there is an inherently higher rate of mechanical complications associated with peripheral catheters. A recent large veterinary study found peripherally or centrally placed saphenous venous catheters to be associated with a higher rate of mechanical complications when compared to jugular venous catheters.[6] Another possibility for the higher mechanical complication rate with this form of PN is the high osmolality and acidity of this solution relative to lipid-containing PN solutions, as both of these factors were thought to contribute to thrombophlebitis.[8] However, a study in people showed that a higher osmolarity solution (1,700 mOsmol/L) did not increase the risk of thrombophlebitis when compared to standard solutions (1,200 mOsmol/L).[34] A canine study reporting the use of a peripherally administered, lipid-containing PN solution of lower osmolarity (840 mOsmol/L) reported a similarly high rate of mechanical complications,[35] suggesting that osmolarity alone may not be the underlying cause of these mechanical complications.

The aim of the study was to evaluate both the feasibility and risks of administering a ready-made lipid-free PN solution to ill hospitalized dogs. It should be noted that this PN solution was administered under stringent conditions in a hospital with established guidelines for preventing and managing mechanical, metabolic and septic complications. It is thus conceivable that if this PN solution is used under less rigorous conditions the rate of complications may be higher. Although there are several other amino acid- and dextrose-containing ready-made PN solutions available, these alternatives may vary in several ways (eg, macronutrient content, electrolyte concentrations, osmolarity) to the product investigated here and as such one cannot assume similar outcomes or levels of complications.

The use of PN in some practices may be hampered by a lack of expertise in formulating and administering PN, lack of monitoring capabilities and the relative expense of this form of nutrition. The ready-made PN solution described in this report may thus provide a less expensive and more convenient form of PN when compared to standard compounded admixtures. However, it is important to stress that this form of PN can be associated with a high rate of complications and as such, patients receiving this PN solution still require close monitoring. Future evaluation of the potential use of ready-made PN solutions and similar solutions are warranted in order to determine optimal modes of administration, and ways to minimize complications. Likewise, establishing a consensus of guidelines for the safe administration and monitoring of PN in animals is necessary to advance this form of nutritional intervention.

Footnotes

[a] Vamin 9 Glucose Solution for Infusion, Fresenius Kabi, Runcorn, Cheshire, UK.
[b] Jelco IV catheters, Smiths Medical, Ashford, Kent, UK.
[c] Long-term catheters, Mila International, Erlanger, KY.
[d] SPSS Statistics for Windows, Version 17.0, SPSS Inc, Chicago, IL.

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