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Retrospective Study

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Retrospective evaluation of ProcalAmine administration in a population of hospitalized ICU dogs: 36 cases (2010–2013)

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Abstract

Objective – To describe the use of ProcalAmine as a source of parenteral nutrition in hospitalized dogs and to report complications possibly referable to its use.
Design – Retrospective study.
Settings – Private veterinary teaching hospital.
Animals – Thirty-six dogs hospitalized in ICU receiving ProcalAmine between October 2010 and March 2013.
Interventions – None.
Measurements and Main Results – The most common underlying disease process in this population of dogs was trauma ($n = 8$). Median duration of administration was 4 days and median resting energy requirement provided via ProcalAmine was 33%. ProcalAmine was administered via central catheters in 86% of cases and via peripheral catheters in 14% of cases. The overall mechanical complication rate was 19%. Metabolic complications possibly associated with ProcalAmine administration were documented in 12/36 dogs. Hyponatremia was most commonly identified ($n = 6$) followed by hyperglycemia ($n = 4$), hypochloremia ($n = 2$), azotemia ($n = 2$), metabolic alkalosis ($n = 2$), hyperchloremia ($n = 1$), and metabolic acidosis ($n = 1$).
Conclusion – ProcalAmine appears to be relatively safe and a viable option for parenteral nutrition in ill and injured dogs. Due to the potential for electrolyte derangements and other metabolic complications, daily monitoring of these parameters is advisable.

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Keywords: amino acids, parenteral nutrition, protein, PPN, TPN

Abbreviations

BCS	body condition score
Creat	creatinine
EN	enteral nutrition
PN	parenteral nutrition
PPN	partial parenteral nutrition
RER	resting energy requirement
TPN	total parenteral nutrition

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Introduction

Malnutrition, protein catabolism, and gastrointestinal abnormalities (eg, vomiting, diarrhea) are common in both human and small animal ICU patients. In critically ill human patients, it is well accepted that early provision of nutritional support is essential for adequate wound repair, organ function, and patient recovery.[1,2] Increased morbidity and mortality in malnourished veterinary ICU patients has not been evaluated specifically; however, studies suggest that these patients may be at risk for a worse outcome.[3–6] The metabolic response to critical illness or injury can be described by an initial hypometabolic response or ebb phase, followed by a protracted hypermetabolic response or flow phase.[7] The ebb phase is defined as a period of hemodynamic instability that is associated with decreased energy expenditure and mild protein catabolism. Once a critically ill patient has been resuscitated and is hemodynamically stable, they enter the flow phase.[7] This phase is associated with significant metabolic alterations including increased energy expenditure, hyperglycemia, and insulin resistance,

brought about by higher circulating levels of the counterregulatory hormones, glucagon, norepinephrine, epinephrine, and growth hormone.[1,8,9] Additionally, patients in the flow phase experience profound protein catabolism that leads to a negative nitrogen balance.[9] Nutritional intervention during this phase may mitigate or even reverse deleterious effects associated with breakdown of essential endogenous proteins.[1,7–9]

Energy requirements can be addressed via provision of either enteral nutrition (EN), parenteral nutrition (PN), or both. While EN is recommended whenever feasible, in certain situations, implementation of PN is preferable. PN is appropriate as a sole means of energy provision in small animals when patients exhibit intolerance to enteral feeding (eg, vomiting, regurgitation) or when contraindications to gastrointestinal tract usage exist (eg, gastrointestinal obstruction, high risk of aspiration as with reduced or absent cough or gag reflexes).[10,11] PN can also be utilized as an adjunct to EN (eg, highly catabolic patients as additional caloric support to supplement enteral feeding).[10,11]

Historically, PN solutions were classified as total parenteral nutrition (TPN), defined as a solution supplying all of a patient's nutritional requirements, or partial parenteral nutrition (PPN), which supplies only a portion of these requirements.[12] With TPN solutions, provision of all of a patient's protein, caloric, and micronutrient requirements should be met.[8,10,12] Recently, there has been a shift in the terminology associated with PN and solutions are now defined by their composition and mode of delivery. For veterinary patients, formulated PN solutions do not typically meet all vitamin and other micronutrient requirements (an essential prerequisite for human patients requiring chronic or lifelong PN) and therefore do not meet the definition of TPN solutions.[13] Energy sources commonly utilized in PN formulations include dextrose, glycerol, amino acids, and lipid.[10,13–15] Total nutrient admixtures are PN formulations that are comprised of amino acids, lipid, and carbohydrates, and can provide 100% of patients' resting energy requirements (RER).[12] Alternatively, there are PN formulations that exclude the lipid component (eg, ProcalAmine[a] or Vamin 9[b]) that can provide between 30 and 70% of RER.[12,14,15]

Ease of administration, cost, and availability of formulations are factors to consider when selecting a PN solution once the parenteral route of nutritional support has been selected. ProcalAmine, while moderately hyperosmolar, can be administered peripherally, obviating placement of the central IV line that is necessary for administration of many other PN formulations.[12,16] Additionally, ProcalAmine is inexpensive, readily-available, and does not require compounding, making it a convenient alternative to most other compounded PN solutions.[16]

The primary objective of this retrospective study was to describe the use of ProcalAmine as a source of PN in hospitalized canine ICU patients. The authors sought to describe patient demographics, indications for provision of PN (eg, patient nutritional status and underlying disease process), administration techniques (eg, catheter site and characteristics, dose of PN, and treatment duration), supplemental enteral nutrition provided, complications possibly associated with ProcalAmine administration (eg, mechanical, metabolic, or septic), and patient outcome.

Material and Methods

Patient selection

All canine patients admitted to the hospital ICU between October 2010 and March 2013 who received ProcalAmine during their hospitalization were eligible for enrollment. Patients administered ProcalAmine prior to October 2011 were identified using the hospital's AS400[b] database program. In November 2011, an ICU ProcalAmine administration log was implemented to improve data capture. Patients were excluded from the study if duration of ProcalAmine administration was less than 24 hours, the administration of this solution was cyclic, or medical records were missing or incomplete.

Data collection

Data collected to characterize patient demographics included signalment, body weight (BW), body condition score (BCS), underlying disease processes, and reasons for ProcalAmine administration. Data collected to describe administration of ProcalAmine included catheter type, time from ICU admission to the initiation of ProcalAmine, duration of administration, and percentage of calculated RER supplied by ProcalAmine. Type of adjunctive EN, estimated percent of calculated RER supplied by EN, and additional IV fluid therapy provided was also reported.

Complications possibly associated with ProcalAmine administration were classified as metabolic, mechanical, or septic. Metabolic complications were defined as clinicopathologic values that deviated outside established reference ranges after initiation of ProcalAmine therapy, irrespective of clinical relevance. To identify this type of complication, daily monitoring of electrolytes, blood glucose, bicarbonate, base excess, and pH values was undertaken. Whenever available, BUN and creatinine (Creat) were also recorded. Reference intervals used in this study were as follows: potassium 3.7–5.4 mmol/L [3.7–5.4 mEq/L]; sodium 142–157 mmol/L [142–157 mEq/L]; chloride 108–125 mmol/L [108–125 mEq/L];

Table 1: Detailed description of amino acid content and concentration in ProcalAmine, a lipid-free ready-made form of parenteral nutrition

Essential amino acids	Concentration (g/100 mL)
Isoleucine USP	0.21 g
Leucine USP	0.27 g
Lysine	0.22 g
(added as lysine acetate USP)	(0.31 g)
Methionine USP	0.16 g
Phenylalanine USP	0.17 g
Threonine USP	0.12 g
Tryptophan USP	0.046 g
Valine USP	0.20 g
Alanine USP	0.21 g
Glycine USP	0.42 g
Arginine USP	0.29 g
Histidine USP	0.085 g
Proline USP	0.34 g
Serine USP	0.18 g
Cysteine	<0.014

glucose 3.4–6.6 mmol/L[63–120 mg/dL]; bicarbonate 18–26 mmol/L [18–26 mEq/L]; standard base excess –4 to +4; pH 7.37–7.46; BUN 3.2–11 mmol/L (9–31 mg/dL); and Creat 38.1–175.4 micromol/L [0.5–2.3 mg/dL]. Mechanical complications were categorized as phlebitis/thrombosis, dislodgement of the catheter or catheter occlusion.

Septic complications were defined as those where catheter related blood stream infection was suspected due to the presence of pyrexia or left shift not attributable to the underlying disease process, which may or may not have been confirmed by positive growth of organisms from blood or catheter tip. For each patient, duration of ICU hospitalization and outcome (eg, discharge or death/euthanasia) were recorded.

Procedures

Solution characteristics

ProcalAmine is a ready-made amino acid and glycerol solution that has an osmolarity of 735 mOsmol/L. This solution contains 24.5 mmol/L (24.5 mEq/L) of potassium, 41 mmol/L (41 mEq/L) of chloride, 35 mmol/L (35 mEq/L) of sodium, 0.75 mmol/L (3 mEq/L) of calcium, 2.5 mmol/L (5 mEq/L) of magnesium, and 3.5 mmol/L (7 mEq/L) of phosphate. ProcalAmine is a 3% amino acid and 3% glycerol solution (Table 1). The protein, glycerol, and mineral content contribute to its moderate hyperosmolarity. The solution has an acidic pH of 6.8 despite being buffered by acetate. ProcalAmine is supplied in 1 L bottles, each providing 0.25 kcal/mL of energy.

Administration

The decision to implement therapy with ProcalAmine, as well as the chosen route of administration and dosing calculations, were at the discretion of the attending clinician. ProcalAmine was administrated either through a peripheral or central intravenous catheter. Various catheter types[c,d,e] were utilized for the administration of ProcalAmine.

Dose

Each patient's RER was calculated using one of the two formulas: RER (kcal/d) = 70 × (current body wt in kg)$^{0.75}$ or if the dog weighed between 2 and 30 kg an alternate formula was acceptable: RER = (30 × body wt in kg) + 70. Additionally, the proportion of RER provided by ProcalAmine was calculated using the formulas: Energy provided per day by ProcalAmine = 0.25 kcal/mL × mL/h × 24 h, and the proportion (%) of RER provided by ProcalAmine per day = energy provided by ProcalAmine ÷ RER × 100. When ProcalAmine rate adjustments were made during the course of hospitalization, the average percentage of RER provided was utilized for purposes of data analyses.

Statistical analysis

Statistical analysis was performed using commercial software.[f] Nominal data were expressed as frequency, percentage, or both. Continuous data were expressed as median and range.

Results

Over a 3-year period, 57 dogs received ProcalAmine; 36 were included in the current study. Twenty-one dogs were excluded for missing or incomplete medical records ($n = 17$), cyclic ProcalAmine administration ($n = 1$), or when ProcalAmine was administered for less than 24 hours ($n = 3$). This study included 20 male and 16 female dogs. Thirteen were male neutered, 7 male intact, 12 female neutered, and 4 female intact. The median age was 8.5 years (range, 12 weeks–15 years). The most common breed was mixed ($n = 7$) followed by Yorkshire Terrier ($n = 4$), Labrador Retriever ($n = 3$), Havanese ($n = 2$), Maltese ($n = 2$), Bischon ($n = 2$), and German Shepherd Dog ($n = 2$). Median BCS at initiation of ProcalAmine was 4/9 (range, 2–7). Median body weight was 10 kg (range, 0.8–51.6 kg).

Underlying disease processes were variable, with trauma being the most commonly observed in this patient population (Table 2). Twenty-five percent of patients ($n = 9$) had 2 underlying disease processes, with pneumonia as one of the 2 primary clinical maladies in 4

Table 2: Details of underlying disease processes in 36 dogs hospitalized in ICU and receiving ProcalAmine, as a source of parenteral nutrition

Disease	Dogs ($n = 36$)
Pancreatic*	5
Gastrointestinal	4
Liver/spleen	3
Renal/urogenital	4
Hematologic	3
Trauma	8
Respiratory	7
Neurologic	6
Septic process	2
Dermatologic§	1
Other ‖	2
Total	45¶

*Included pancreatitis, DKA/DM, pancreatic pseudocyst.
§Included erythema multiforme.
‖Included retroperitonitis ($n = 1$) and nonspecified acute abdomen ($n = 1$).
¶Nine dogs had 2 primary disease processes.

Table 3: Details of metabolic complications recorded following initiation of ProcalAmine, as a source of parenteral nutrition in 36 dogs hospitalized in the ICU

Metabolic complication	Number of dogs affected
Hyperglycemia	2
Hyponatremia	3
Hypochloidemia	1
Hyponatremia and hypochloridemia	1
Metabolic alkalosis	2
Metabolic acidosis, hyperchloridemia, and hyponatremia	1
Azotemia, hyperglycemia, and hyponatremia	1
Azotemia and hyperglycemia	1
Total	12

of these 9 dogs (44%). Median duration of anorexia or hyporexia prior to initiation of ProcalAmine was 3.5 days (range, 0–19 days). Reasons for initiation of ProcalAmine included anorexia ($n = 21$, 58%), hyporexia ($n = 10$, 28%), or deliberate oral intake restrictions ($n = 5$, 14%) in patients mechanically ventilated, mentally inappropriate, or demonstrating enteral feeding intolerance.

ProcalAmine was administered through a peripheral catheter in 5/36 dogs (14%) and via a central catheter in 31/36 dogs (86%). The median time from ICU admission to the initiation of ProcalAmine was 3 days (range, 0–4 days) and the median length of ProcalAmine administration was 4 days (range, 2–11 days).The median percent of RER provided by ProcalAmine was 33% (range, 16–75%). Concurrent supplemental enteral feedings were administered in 31/36 (86%) dogs. Sixty-four percent (23/36) of dogs received free choice per os feedings and 22% (8/36) were fed via a feeding tube (esophagostomy tube, $n = 3$; gastrostomy tube, $n = 4$; and nasogastric tube, $n = 1$). Estimated percentage of RER supplied by concurrent enteral nutrition was less than 25% in 21 dogs, 25–50% in 12 dogs, and 50–75% in 3 dogs. Ninety-eight percent of patients received concurrent IV fluids. Thirty-six percent received isotonic crystalloids while 58% received synthetic colloids. The median rates (mL/kg/day) of isotonic crystalloid and synthetic colloid administration were 39 (range, 17–61) and 25 (range, 17–52), respectively.

Mechanical complications possibly associated with ProcalAmine administration were documented in 7 dogs (19%). Phlebitis was the most common complication ($n = 5$) followed by catheter obstruction/dislodgement of the catheter ($n = 2$). Phlebitis was appreciated in 60% of dogs (3/5) that received ProcalAmine peripherally and 40% of dogs (2/5) who had central lines in place.

Metabolic complications occurring possibly in association with ProcalAmine administration were documented in 12 dogs (Table 3). These were documented solely or in combination with other metabolic abnormalities. Hyponatremia ($n = 6$) was the most common metabolic derangement noted, followed by hyperglycemia ($n = 4$). No septic complications were documented.

Outcome

The median length of hospitalization was 6.5 days (range, 3–15 days). Thirty-one dogs (86%) survived to discharge, 3 were euthanized, and 2 died during hospitalization.

Discussion

In the current study, the most common primary disease process in dogs receiving PN in the form of ProcalAmine was trauma. This differs from previous reviews of PN in small animals that documented pancreatitis as the most common primary disease process.[17–19] The urban location of this hospital may, in part, account for this difference in patient cohorts. Additionally, the preferential use of EN over PN in most pancreatitic patients in recent years may help explain the change in patients selected for PN administration.[20,21] Polytrauma can result in a marked stress response and significant protein catabolism. Affected patients often have concurrent head trauma, facial injury, or insult to intraabdominal organs, all of which can interfere with safe and effective delivery of EN. Administration of parenteral opioids can reduce or exacerbate gastrointestinal dysfunction and lead to enteral feeding intolerance. For these reasons, ProcalAmine and other forms of PN may be a viable option for nutritional

supplementation in the initial days of hospitalization of traumatized patients, until such time when EN can be instituted adjunctively or as a sole therapy.

In the current study, there was an overall mechanical complication rate of 19%, compared to a 40% mechanical complication rate reported in a recent study by Gajanayake et al that evaluated a similar lipid-free ready-made PN solution, Vamin 9.[19] In both studies, mechanical complications occurred more commonly following peripheral administration of PN. In contrast to the aforementioned study, which reported catheter dislodgement as the most common mechanical complication, phlebitis accounted for the majority of mechanical complications in the current study. Risk factors for the development of phlebitis can be catheter-specific (eg, catheter material, size, or intravenous infusate) or patient-specific (eg, underlying disease, catheter insertion site).[22,23] Catheter type utilized for administration of PN solution was not evaluated in either study, but certain catheter materials are more likely to cause thrombophlebitis than others. Studies have demonstrated that polyurethane catheters are associated with a 30–40% reduction in the incidence of peripheral vein infusion thrombophlebitis compared with tetrafluoroethylene-hexafluoropropylene (Teflon) catheters.[22] Low pH and high osmolarity, properties of lipid-free PN solutions such as ProcalAmine or Vamin 9, can increase risk of phlebitis.[24] ProcalAmine and Vamin 9 have acidic pH of 6.9 and 5.2, respectively, as well as relatively high osmolarities (735 and 1,350 mOsmol/L, respectively). Solutions with a low pH can lead to venous endothelial cell damage at sites distal to the catheter tip. This damage is thought to occur because more time is required for the hydrogen ion content of the solution being infused to be neutralized by the blood. Administration of hypertonic solutions draws fluid from the endothelium and blood cells causing them to shrink and making them susceptible to additional damage. The degree and onset of damage is determined by a solution's osmolarity. While the notable differences in acidity and osmolarity of ProcalAmine compared to Vamin 9 might suggest that phlebitis would be more commonly observed following administration of the latter, this was not the case when comparing our study to that by Gajanayake et al.[19]

Catheter insertion site may also affect occurrence of phlebitis. Peripheral veins are smaller and have decreased blood flow rates compared to central veins making them more susceptible to trauma and subsequent phlebitis. In the study by Gajanayake et al,[19] 66% of patients received PN through a peripheral catheter, compared to the current study where the majority of patients (86%) received ProcalAmine centrally. While the majority of patients in the current study receiving ProcalAmine peripherally developed phlebitis, this was not a commonly-reported problem associated with peripheral administration of PN in the study by Gajanayake et al.[19] The development of phlebitis may increase the patient's risk of local catheter-related infection warranting strategies to minimize occurrence in critically ill patients.[24]

In the current study, the median percent RER provided by ProcalAmine was 33% (range, 16–75%). ProcalAmine was used as an adjunct nutritional supplement in 86% of patients. Thirty-six percent received an estimated 25–50% of RER in the form of EN. While there is a subset of critically-ill patients in whom PN is the preferred or only viable option for nutritional support, EN is considered the superior route of nutritional supplementation in the vast majority of patients. In this study, specific contraindications to EN did not exist in many of the included dogs. However, clinician or owner preference, convenience, and finances resulted in preferential selection of PN over EN.

The PN formulations available for use in critically ill veterinary patients vary significantly in composition. As current and preexisting disease processes contribute to the metabolic complications associated with PN administration, individual patient factors must be considered when selecting a particular PN solution. For example, patients with aberrations in renal or hepatic function may be intolerant to the high amino acid concentrations found in ProcalAmine. Renal failure and severe liver disease are contraindications for the use of ProcalAmine according to the manufacturer.[16] Increases in BUN concentration can be seen with administration of amino acids, and this metabolic alteration may be exacerbated by renal impairment. In the current study, 2 patients had an increase in serum BUN and creatinine concentration while receiving ProcalAmine.

Most PN formulations contain dextrose or glycerol, and hyperglycemia is a common metabolic complication associated with PN. Many critically ill patients have insulin resistance and glucose intolerance. Additionally, a percentage of patients requiring PN (both in this study and in the general veterinary ICU patient population) are diabetic and hyperglycemic on hospital admission. Minimizing the development of hyperglycemia in patients receiving PN may be important, as this metabolic derangement has been demonstrated in both human and veterinary medicine to be associated with poor outcome.[25–27] Studies evaluating the use of PN solutions in clinical veterinary patients are limited; however, the most recent studies similarly concluded that the most common metabolic complication associated with PN was hyperglycemia.[3,17,28–30] In the current study, 4 of 36 patients with normal glucose values prior to ProcalAmine infusion developed hyperglycemia following administration of this PPN solution. The clinical significance of this finding is questionable, however, as these

dogs exhibited mild hyperglycemia (< 9.9 mmol/L [180 mg/dL]) that did not prompt clinical intervention. ProcalAmine contains 30g/L of glycerol compared to Vamin 9 that contains 100 g/L of glucose. The lower carbohydrate concentration of ProcalAmine may help explain decreased occurrence of hyperglycemia in our study compared to what was observed in the study by Gajanayke et al,[19] which documented hyperglycemia in 24 of 67 dogs.

There are several methods of minimizing hyperglycemia in patients receiving PN. Recognition of progressive increases in blood glucose in patients on PN may necessitate reevaluation of the PN formulation being utilized. For example, solutions can be formulated with 5% versus 50% dextrose, or incorporate glycerol instead of dextrose, for use as a carbohydrate source. ProcalAmine, one such glycerol-containing solution, requires less exogenous insulin to maintain plasma glucose homeostasis compared to dextrose-containing PN solutions.[14] Glycerol participates as an active energy substrate through phosphorylation to alpha glycerophosphate and subsequent conversion to dihydroxyacetone.[31] An earlier human study demonstrated that insulin treated diabetic patients receiving ProcalAmine postoperatively required less insulin compared to those receiving FreeAmineIII (an amino acid injection) combined with dextrose supplementation.[32] Administration of intermittent regular insulin as needed in patients receiving PN to maintain blood glucose < 9.9 mmol/L (180 mg/dL) can help avoid severe hyperglycemia and its adverse effects.

Another metabolic complication that may be associated with administration of PN solutions includes acid–base derangements. To the authors' knowledge, previous reviews of PN in veterinary patients have not specifically evaluated or reported acid–base aberrations possibly attributable to this therapy.[3,17,28–30] Metabolic acidosis is commonly reported in human patients receiving prolonged PN.[33,34] Acidosis associated with PN is multifactorial, but is in part associated with metabolism of cationic or sulfa-containing amino acids present in PN formulations. While patients with normal respiratory and renal function should be capable of excreting acids produced from amino acid metabolism, those with increased renal or gastrointestinal loss of bicarbonate or diminished renal excretory function may develop a metabolic acidosis while on long-term PN.[35,36] ProcalAmine contains potentially acidifying amino acids. However, hydrogen ions generated from amino acid catabolism can be neutralized by acetate also contained in this PN solution, and the presence of this buffer may help explain the infrequent development of metabolic acidosis observed in our patient population ($n = 1$). Additionally, the small number of reported acid–base derangements may be the result of the short term use of ProcalAmine in the current study.

Six patients exhibited hyponatremia following ProcalAmine administration and 2 patients exhibited hypochloremia. Patient factors such as intravascular volume depletion and subsequent nonosmotic release of anti-diuretic hormone and electrolyte losses through the gastrointestinal tract or kidneys are possible contributing causes for this finding. Additionally, the observed changes in these 2 electrolytes can be explained in part through evaluation of electrolyte concentrations in ProcalAmine. ProcalAmine is similar in sodium and chloride composition to a maintenance crystalloid fluid. Maintenance fluids (eg, Normosol M, half-strength saline with 2.5% dextrose) are typically used to support obligate fluid losses in hydrated patients requiring IV fluid therapy and contain less sodium, chloride, and more potassium than replacement solutions.[37] ProcalAmine functioned as the predominant crystalloid fluid administered to our study patients, typically infused at maintenance or in excess of maintenance fluid rates (60–90 mL/kg/day). Synthetic colloids (eg, Hespan, VetStarch) were the most common concurrent solutions utilized in this study, administered to over 50% of the patients. While these hydroxyethylstarches are 0.9% saline-based, they were administered at fairly low infusion rates (eg, 20–40 mL/kg/day). It is possible that preexisting whole body electrolyte deficiencies and/or ongoing losses of these same electrolytes associated with patient primary disease process were not adequately addressed via provision of ProcalAmine as a primary crystalloid fluid, and that concurrent infusion of replacement, isotonic crystalloids were indicated in more of our patients. The clinical relevance of these electrolyte abnormalities is questionable, as aberrations were mild and associated clinical signs were not observed. The relatively short infusion periods compared to that often encountered in human patients receiving PN may, in part, explain the absence of clinically significant hyponatremia or hypochloremia in this population. Longer infusion times with ProcalAmine, especially if administered as the primary source of sodium and chloride in critically ill patients, may have resulted in more significant alterations.

Gajanayake et al demonstrated hyperkalemia in 16 of 67 dogs, and development of this electrolyte derangement was associated with a worse outcome.[19] In their study, 63% of hyperkalemic dogs were receiving additional potassium supplementation. The observed hyperkalemia in these dogs was mild, and no clinical signs referable to this electrolyte abnormality were reported.[19] Vamin 9 and ProcalAmine contain 20 mEq/L and 25 mEq/L of potassium, respectively. Given the slightly higher concentration of potassium in ProcalAmine

compared to most other standard intravenous fluid solutions, the development of some degree of hyperkalemia might be expected. However, hyperkalemia was not observed in any dog included in the current study.

ProcalAmine provides a physiologic ratio of utilizable amino acids as well as a source of nonprotein energy (glycerol).[16] The amino acid component can be utilized for protein synthesis and studies demonstrate it can improve nitrogen balance in mild to moderately malnourished human patients.[38–42] During starvation, there is an initial increase in hepatic glycogenolysis and gluconeogenesis in order to maintain blood glucose homeostasis. Once glycogen stores are depleted, the body begins breaking down endogenous protein for amino acids that can be utilized for gluconeogenesis. This ultimately can result in a negative nitrogen balance.[1,9,43–45] A previous double-blinded human study evaluating the safety and efficacy of ProcalAmine concluded that it was safe and was associated with improved nitrogen balance both on a daily and cumulative basis in the ProcalAmine group.[42] It is important to note that this study was not in a population of critically ill patients. Nitrogen balance was not evaluated in this study due the retrospective nature. Further prospective veterinary studies evaluating nitrogen balance and ProcalAmine's purported nitrogen sparing effects are warranted.

Limitations of the current study include its retrospective nature, small sample size, and presence of confounding factors, such as underlying disease and concurrent fluid therapy. Patient and treatment factors preclude attributing specific metabolic complications to ProcalAmine itself. An in vivo study on healthy patients receiving ProcalAmine might be more effective at truly assessing the effect of PN on these parameters. The lack of readily available objective methods of assessing nutritional status in veterinary medicine and reliance on nonspecific and subjective parameters also limit evaluation of the effect of PN on sick animals. Determination of what particular alteration in blood values (eg, electrolytes, glucose, and changes in renal/hepatic values) constitute clinically significant abnormalities and are attributable to PN is somewhat arbitrary and clinician dependent, further complicating data interpretation. Future prospective and clinical studies are recommended to better evaluate the potential benefits and complications associated with the use of ProcalAmine, as well as to establish optimal and standardized administration protocols that reduce the incidence of mechanical complications.

Our study suggests that ProcalAmine is relatively safe to use and provides a viable short term PN option in ill and injured dogs. It may best be utilized as a supplement to EN. Due to the potential for electrolyte, acid base, and blood glucose derangements, serial monitoring of these blood parameters is advisable.

Footnotes

[a] ProcalAmine, B. Braun Medical Inc., Bethlehem, PA.
[b] Application System/400 (AS/400), IBM Corp., Armonk, NY.
[c] SURFLO ETFE IV peripheral catheter, Terumo Medical Corp., Somerset, NJ.
[d] IntracathTM single lumen central catheter, Deseret Pharmaceutical Company Inc., Salt Lake City, UT.
[e] ARROW multi-lumen catheter, Teleflex Inc., CA.
[f] SigmaStat, version 3.5, Systat Software Inc., Richmond, CA.

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