Retrospective Evaluation of Partial Parenteral Nutrition in Dogs and Cats

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The purpose of this retrospective study was to evaluate the use of partial parenteral nutrition (PPN) in dogs and cats. The medical records of all dogs and cats receiving PPN between 1994 and 1999 were reviewed to determine signalment, reasons for use of PPN, duration of PPN administration, duration of hospitalization, complications, and mortality. Complications were classified as metabolic, mechanical, or septic. One hundred twenty-seven animals (80 dogs and 47 cats) were included in the study, accounting for 443 patient days of PPN. The most common underlying diseases were pancreatitis (n = 41), gastrointestinal disease (n = 33), and hepatic disease (n = 23). Median time of hospitalization before initiation of PPN was 2.8 days (range, 0.2–10.7 days). Median duration of PPN administration was 3.0 days (range, 0.3–8.8 days). Median duration of hospitalization was 7 days (range, 2–20 days). In the 127 animals receiving PPN, 72 complications occurred. These included metabolic (n = 43), mechanical (n = 25), and septic (n = 4) complications. The most common metabolic complication was hyperglycemia (n = 19), followed by lipemia (n = 17) and hyperbilirubinemia (n = 6). Most complications were mild and did not require discontinuation of PPN. Ninety-three (73.2%) of the 127 patients were discharged. All 4 animals with septic complications were discharged from the hospital. The presence, type, and number of complications did not impact the duration of hospitalization or outcome. However, animals that received supplemental enteral nutrition survived more often than those receiving PPN exclusively. Although PPN seems to be a relatively safe method of providing nutritional support, future studies are warranted to determine its efficacy.

Key words: Cat; Dog; Intravenous feeding; Nutritional support.

The metabolic response to illness or injury puts critically ill animals at risk for malnutrition and its deleterious effects such as alterations in energy metabolism, compromised immune function, and decreased wound healing.[1–5] Malnutrition is a common problem in critically ill animals because of several factors, including poor appetite, vomiting, inability to eat or tolerate feedings, and decreased absorptive capabilities.[2,6] The goals of nutritional support of critically ill patients are to treat malnutrition when present and to prevent malnutrition in patients at risk.[5–9] Although unproven in dogs and cats, treatment or prevention of malnutrition is thought to decrease morbidity and mortality.[5–9] Although enteral nutrition is the preferred method of nutritional support in critically ill patients, parenteral nutrition is the established method for providing nutritional support to patients whose gastrointestinal tracts cannot tolerate enteral feeding.[1–4,8,10]

Total parenteral nutrition (TPN) is the provision of all essential nutrients by the intravenous route, whereas partial parenteral nutrition (PPN) only supplies part of the nutritional requirement of the patient.[1–2,10] PPN can be administered through a peripheral vein, and sometimes is called peripheral parenteral nutrition. In this paper, we use the abbreviation PPN to refer to partial parenteral nutrition. Generally, PPN has been recommended for short-term nutritional support in nondebilitated patients (ie, those without obvious signs of malnutrition).[1,10] Other indications for PPN include nutritional support of patients in which central jugular catheter placement is contraindicated and to supplement enteral feeding when it is insufficient to meet the full nutritional needs of the patient.

Use of TPN previously has been reported in dogs and cats,[7,8] but PPN has not been similarly evaluated. The purpose of this retrospective study was to evaluate and characterize the use of PPN in dogs and cats. Patient profile, frequency and type of complications associated with PPN administration, and short-term outcome were evaluated.

Materials and Methods

Patient Selection

The medical records of all dogs and cats receiving PPN between September 1994 and December 1999 were reviewed. These animals were identified from a nutritional support log kept at the Foster Hospital for Small Animals. Patients were excluded from the study if the medical record could not be located or if they received cyclic PPN administration (ie, infusions for 12-hour cycles). Patients receiving some enteral nutrition during the time PPN was administered were not excluded from the study because 1 of the indications for PPN is to supplement enteral nutrition.

Procedures

The standard procedure for PPN administration in our hospital is to place a dedicated parenteral nutrition catheter[a–d] by using aseptic technique in the external jugular, lateral saphenous, femoral, or cephalic vein. Once PPN administration begins, the catheter is not used for any other purpose. Bags and lines are changed every 24 hours by using aseptic technique, and PPN is administered through a 1.2-μm filter.[e] The patient's daily caloric requirements are calculated with standardized worksheets that utilize the following formula: resting energy requirement (RER) = 70 × (body weight in kg)$^{0.75}$ or RER = 30 × (body weight in kg) + 70.[1,2] The illness energy requirement (IER) is estimated as a multiplier of RER (IER = 1.0–1.5).[1,2] A partial energy requirement (PER) then is calculated as 50% × IER and PER then is provided to the animal with 5% dextrose, 8.5% amino acids,[f] and 20% lipid[g] solutions.[1] The final calculated osmolarity of the PPN solution is kept lower than 750 mosm/L. The proportions of each component used in the formulation of PPN for each patient are determined in

Table 1. Partial parenteral nutrition (PPN) formulations used based on body weight. Some animals received a customized PPN formulation.

| Body Weight (kg) | Percent of Calories from each Component | | | Formulation | n[a] |
	5% Dextrose	8.5% Amino Acids	20% Lipid		
3–10	25	25	50	A	52
10–25	33	33	33	B	19
<25	50	25	25	C	23
Custom[b]	Variable	Variable	Variable	D	19

[a] The specific formula was not available in the medical record for 14 animals.

[b] These formulas ranged from 15 to 85% of calories from dextrose, 8 to 33% of calories from amino acids, and 0 to 48% of calories from lipid.

accordance with a standardized chart (Table 1).[1] These formulations were developed by the Nutrition Service at the Foster Hospital for Small Animals and were designed to partially meet caloric, protein, vitamin, and mineral requirements while approximating maintenance fluid requirements for animals of various sizes.[1] Some animals that required specific adjustments to the standard PPN (eg, those with hepatic failure or severe hypoproteinemia) received a customized PPN formulation (Table 1). The PPN solution was compounded aseptically as a total nutrient admixture by using a commercial closed-system compounder.[h] TPN multivitamins[i] and trace metals[j] were added to most but not all PPN formulations depending upon clinician preference (generally 0.5 mL/5 kg, up to 5 mL/animal). The total nutrient admixture was administered immediately after compounding, or stored at 4°C for a maximum of 120 hours. In most cases, PPN was started at full strength (ie, without incremental increases in volume) and discontinued when enteral intake was deemed adequate to support the patient's nutritional requirements.

Data collected from the medical records included the patient's signalment, body weight, history, presenting complaint(s), primary medical problem(s), catheter type and location used, and available clinicopathologic data. Additional information retrieved from the medical record included illness factor used, days without food intake before PPN, days of hospitalization before PPN initiation, total length of hospitalization, length of PPN administration, body weight changes, final outcome, and complications incurred during PPN administration. Days without food intake were determined by counting the number of days from the time the animal stopped eating (which could have been before presentation) until nutritional support was initiated.

Complications associated with PPN administration were classified as mechanical, septic, or metabolic. Mechanical complications included thrombophlebitis, catheter occlusions, disconnected lines, or any technical problem interfering with the administration of PPN. Septic complications were characterized by clinical suspicion of sepsis and a positive catheter tip culture. New febrile episodes during PPN administration that could not be attributed to the underlying disease process also were recorded. Metabolic complications were defined as increases in serum glucose, triglyceride, bilirubin, urea nitrogen, sodium, chloride, calcium, or phosphorus concentrations after PPN administration in a patient with a measurement that was initially within reference limits.

Statistics

Descriptive data are presented as mean ± SD for normally distributed data and medians (range) for skewed data. The distributions of data were examined graphically. Data not normally distributed were logarithmically transformed. Chi-square analyses and independent *t*-tests were used for categorical and continuous data, respectively. Pearson correlation tests were used to determine any associations between 2 continuous variables. All statistical tests were done with commercial statistical software.[k] A result was considered statistically significant if $P < .05$.

Results

Patient Demographics

During the 63-month period, 189 animals received PPN. Cases were excluded if the medical record could not be located (n = 56) or if the animal received cyclic PPN (n = 6). Consequently, 127 animals (80 dogs and 47 cats) were included in the study, accounting for a total of 253 and 181 patient days of PPN for dogs and cats, respectively. Mean age was 8.1 ± 3.7 years for dogs (range, 0.4–16.0 years) and 9.5 ± 4.5 years for cats (range, 0.8–18.0 years; Table 2). The study included 40 male dogs (28 castrated), 40 female dogs (35 spayed), 25 male cats (all castrated), and 22 female cats (all spayed; Table 2). Patients received PPN for a variety of reasons and many received PPN for multiple reasons (Table 2). Patients with pancreatitis comprised the largest proportion of patients receiving PPN. Gastrointestinal and hepatobiliary disease also were common underlying disorders (Table 2). Many animals had more than 1 underlying disease.

Before PPN was initiated, the mean time the patient received no food PO was 5.3 ± 2.7 days (Table 3). Twenty-nine animals received enteral nutrition (either by feeding tube [n = 6] or by oral intake [n = 23]) at some point while they were receiving PPN. Animals were categorized based on the maximal percentage of the IER provided by enteral nutrition while receiving PPN: 1–25% (n = 15), 26–50% (n = 6), 51–75% (n = 4), or 76–100% (n = 4). The length of hospitalization before initiation of PPN ranged from 0.2 to 10.7 days (median, 2.8 days; Table 3). The length of hospitalization before starting PPN was significantly shorter in cats than in dogs ($P < .001$; Table 3). The median duration of PPN administration was 3.0 days (range, 0.3–8.8 days; Table 3). Dogs lost significantly more weight than cats ($P = .007$); overall body weight change in all animals was −0.3 ± 1.6 kg (Table 3). Catheter information was available in 120 animals (74 dogs and 46 cats). For the dogs, catheters were placed in the jugular vein (n = 35), saphenous vein (n = 31), femoral vein (n = 5), and cephalic vein (n = 3). For cats, catheters were placed in the jugular vein (n = 26), femoral vein (n = 16), saphenous vein (n = 3), and cephalic vein (n = 1).

The most common complications were metabolic (n = 43), followed by mechanical (n = 25), and septic (n = 4; Table 4). These findings represent 45 complications per 253 days of PPN (0.18 complications per day of PPN) for dogs and 27 complications per 181 days of PPN (0.15 compli-

Table 2. Baseline characteristics and underlying diseases of animals receiving partial parenteral nutrition.

	Dogs	Cats	Total
n	80	47	127
Age (years, mean ± SD)	8.1 ± 3.7	9.5 ± 4.5	8.4 ± 4.1
Gender	F = 40, M = 40	F = 22, M = 25	F = 62, M = 65
Weight (kg, median, [range])	21.3 (2.0–61.8)	4.1 (2.3–9.2)	7.9 (2.0–61.8)
Disease (n [%])			
Pancreatitis	23 (29)	18 (38)	41 (32)
Gastrointestinal[a]	18 (23)	15 (32)	33 (26)
Hepatic	7 (9)	16 (34)	23 (18)
Peritonitis	10 (13)	4 (9)	14 (11)
Endocrine[b]	6 (8)	4 (9)	10 (8)
Renal	6 (8)	3 (6)	9 (7)
Nongastrointestinal neoplasia	6 (8)	3 (6)	9 (7)
Other[c]	20 (25)	4 (9)	24 (19)

F, female; M, male.

[a] Inflammatory bowel disease, gastrointestinal neoplasia, gastroenteritis, ulcers, and esophageal disease.

[b] Diabetes mellitus, hyperthyroidism, and hyperadrenocorticism.

[c] Infectious, immune-mediated disease, trauma, and patients receiving ventilatory support.

cations per day of PPN) for cats. No evidence of an association between illness factor used in the calculation of IER, catheter site, PPN duration, species, body weight, or concurrent enteral nutrition with frequency of complications was found. Hyperglycemia (n = 19) was defined as serum or blood glucose concentration > 120 mg/dL that developed in a patient that was normoglycemic before PPN administration, and was the most common metabolic complication. Other metabolic complications included lipemia (n = 17), hyperbilirubinemia (n = 6), and azotemia (n = 1; Table 4). Except in patients with diabetes mellitus diagnosed before PPN administration, no animals required insulin administration, and transient hyperglycemia lasted 1–3 days. Cats were more likely to have metabolic complications than dogs, but this finding did not reach statistical significance (P = .07). Animals receiving PPN formulation A (Table 1) were significantly more likely to have metabolic complications than animals receiving any of the other 3 formulations (P = .05). Mechanical complications included catheter dislodgement (n = 10), catheter disconnection (n = 8), thrombophlebitis (n = 3), catheter occlusion

(n = 2), and chewed lines (n = 2). The rate of mechanical complications for patients receiving PPN was 26% in dogs and 9% in cats, with an overall mechanical complication rate of 20% (Table 4). Two dogs and 2 cats had confirmed sepsis (clinical suspicion of sepsis plus a positive catheter-tip culture). All patients with septic complications were successfully discharged from the hospital. Four additional animals (2 dogs and 2 cats) also had fever that developed after starting PPN. However, PPN-related sepsis could not be confirmed in these 4 animals. Of the patients with at least 1 complication and in which catheter location could be determined from the medical record, no difference was found between those with central (jugular) catheters (n = 24) and those with peripheral (saphenous, cephalic, or femoral) catheters (n = 22). Also, no differences in mechanical, metabolic, or septic complications were found between animals with central versus peripheral catheters.

Median duration of hospitalization was 7 days (range, 2–20 days; Table 3). No significant difference was found between dogs and cats for hospitalization duration. Overall hospitalization time was positively correlated with the

Table 3. Information on partial parenteral nutrition (PPN) administration in dogs, cats, and for all animals (mean ± SD or median, range).

	Dogs	Cats	Total
Number of patients	80	47	127
Patient days of PPN	253	181	434
Days without food before starting PPN	5.5 ± 2.8	4.9 ± 2.5	5.3 ± 2.7
Days receiving PPN	3.0 (0.3–8.8)	3.1 (0.7–8.4)	3.0 (0.3–8.8)
Days in hospital	8.0 (2–20)	6.0 (2–18)	7.0 (2–20)
Days before starting PPN	3.7 (0.2–10.7)	1.8 (0.4–7.5)[a]	2.8 (0.2–10.7)
Change in body weight (kg)	−0.5 ± 1.9	0.0 ± 0.3[a]	−0.3 ± 1.6
Illness factor used	1.3 ± 0.1	1.4 ± 0.1[a]	1.3 ± 0.1
Outcome (n [%])			
Discharged	55 (69)	38 (81)	93 (73)
Died	9 (11)	5 (10)	14 (11)
Euthanized	16 (20)	4 (9)	20 (16)

[a] P < .05 compared to dogs.

Table 4. Number of complications in 127 animals receiving partial parenteral nutrition.

Complication	Dogs	Cats	Total
Mechanical	21	4	25
Metabolic	22	21	43
Hyperglycemia	10	9	19
Lipemia	8	9	17
Hyperbilirubinemia	3	3	6
Azotemia	1	0	1
Septic	2	2	4
Total	45	27	72

length of hospitalization before starting PPN ($P = .001$). Overall hospitalization time was not associated with body weight changes, complications, illness factor used in the IER calculation, or concurrent enteral feeding.

Fifty-five dogs (69%) and 38 cats (81%) were discharged from the hospital. During hospitalization, 9 dogs and 5 cats died and 16 dogs and 4 cats were euthanized for a variety of reasons, including financial constraints, poor response to therapy, or worsening condition. Overall mortality rates for PPN patients were 31% for dogs and 19% for cats. More animals that received some enteral nutrition during PPN administration survived (26/29) compared to animals not receiving any enteral nutrition (67/98; $P = .023$). No evidence was found of an association between outcome and species, age, complication, change in body weight, illness factor used, duration of hospitalization, or length of hospitalization before starting PPN.

Discussion

One of the proposed advantages of PPN over TPN is lower risk of complications, especially metabolic complications. Mechanical complications such as occluded catheters, line breakage, or disconnections are encountered commonly in veterinary patients receiving TPN.[7,8] The frequency of mechanical complication (ie, number of mechanical complications per total number of patients receiving PPN) in the current study (26% in dogs, 9% in cats, and 20% overall; Table 4) is lower than previously reported rates in dogs receiving TPN (57%)[8] and in dogs and cats receiving TPN (46%).[7] This difference may be due to different parenteral nutrition protocols among hospitals, a lower risk of mechanical complications in PPN compared to TPN, or slightly different categorization of mechanical complications. Although thrombophlebitis is commonly cited as a complication of peripheral parenteral nutrition, only 3 cases were noted in the current study. Future studies to determine methods that can help reduce the occurrence of other mechanical complications in dogs and cats would be useful.

Although dogs were as likely as cats to develop mechanical and metabolic complications, cats were more likely to have metabolic complications. In cats, 78% of all complications observed were classified as metabolic. This finding may be a result of the formulation used for cats (formula A), but metabolic complications were relatively uncommon in small dogs receiving formula A. These dif-

ferences also could have resulted from differences in patient selection and severity of disease rather than the formula used or the species in which it was used. In dogs, transient hyperglycemia was the most common metabolic complication, whereas lipemia and hyperglycemia were equally common in cats. Animals that did not have preexisting diabetes mellitus did not require exogenous insulin during PPN administration. Hyperglycemia accounted for 44% of the metabolic complications and 26% of all complications. The actual prevalence of hyperglycemia in patients receiving PPN was 15%, which is less than that observed in the studies of patients receiving TPN by Reuter et al[8] (32%) and Lippert et al[7] (37%). These differences potentially are due to a lower total dose of dextrose in PPN versus TPN and the provision of a lower percentage of caloric requirements in PPN. Another possibility is that, with increasing severity of illness, patients become more likely to experience metabolic derangements such as glucose intolerance.[11–13] The septic complication rate of PPN patients (ie, number of septic complications per total patients) in the current study (3%) was lower than that reported by Reuter et al[8] (12%). All patients with a septic complication (catheter infection in all 4 patients) in the current study were successfully treated by removal of the catheter and administration of appropriate antibiotics, and were subsequently discharged from the hospital.

Overall, 72 complications were observed during 434 days of PPN administration, translating into 0.17 complications per day of PPN administration (0.18 and 0.15 complications per day of PPN administration in dogs and cats, respectively). Although direct comparisons between this population of patients and those in previous studies cannot be made, the study by Reuter et al[8] reported 473 complications during 895 days of TPN administration, representing 0.53 complication per day of TPN in dogs. The higher complication rate seen with TPN administration could be a reflection of a more severely ill population of patients, because debilitated animals typically would be given TPN rather than PPN. With both PPN and TPN, the potential benefits should be weighed against the risk for complications.

Generally, the recommendations for PPN are short-term support of nondebilitated patients that are unable to fully tolerate enteral feedings. Therefore, it is not surprising that the majority of dogs and cats receiving PPN in the current study exhibited signs of gastrointestinal disease. These findings parallel observations in 2 previous studies of veterinary TPN patients.[7,8] Because patients expected to need more than 5 days of parenteral nutrition are candidates for TPN, it is appropriate that the median duration of PPN administration in the current study was 3.0 and 3.1 days (mean, 3.2 and 3.9 days) for dogs and cats, respectively. Interestingly, these observations are similar to those made in veterinary patients receiving TPN.[7,8] In the study by Reuter et al,[8] dogs received TPN for a mean of 4.4 days, whereas in the study by Lippert et al,[7] the mean duration of TPN administration was 4.5 and 4.6 days in dogs and cats, respectively.

Studies in human patients have shown benefits for early versus delayed enteral nutrition support.[14–18] The potential benefits of early parenteral nutrition are less clear. The me-

dian duration of hospitalization before starting PPN in the current study was 2.8 days and ranged from 0.2 to 10.7 days, whereas in the study by Reuter et al,[8] the median time before initiation of TPN was 1.5 days (range, 0.5–15 days). One possible reason for the difference between these studies is that some patients in our hospital received PPN as an adjunct to enteral nutrition, whereas the study by Reuter et al[8] specifically excluded any patients that received concurrent enteral nutrition. In addition, the decision to initiate parenteral support is based on many variables, which include the underlying disease, nutritional status of the patient, overall function of the gastrointestinal system, and expected clinical course. Patients in the current study may have been less severely ill than patients in previous studies, and immediate nutritional support may not have been indicated. Species difference in the length of hospitalization before PPN therapy also was observed. Cats received PPN earlier in their course of hospitalization, probably reflecting a greater concern for the development of complications such as hepatic lipidosis.

Parenteral nutrition generally is intended to maintain rather than restore lean body mass and prevent further deterioration in nutritional status until adequate intake is achieved. In the current study, dogs lost a mean of 1.0% of initial body weight while receiving PPN and cats gained a mean of 1.5%. In the study by Lippert et al,[7] the mean percentage body weight change was a gain of 4.1% in dogs and 6.4% in cats. If body weight changes in the current study are expressed in terms of absolute weight change, a mean loss of 0.5 kg occurred in dogs (with a mean loss of 0.3 kg in all animals) compared to the study of Reuter et al[8] of dogs, which found a mean weight gain of 0.5 kg. Accrual of lean body mass was unlikely in the short-term duration of feeding in either of the previous studies. The increases in body weight more likely were due to an increase in extracellular water. Changes in body weight in the current study also could have been affected by changes in extracellular water. Similar to the observations made by Reuter et al,[8] changes in weight in the current study did not affect outcome or frequency of complications.

An association between severity of malnutrition and poor outcome has been well established in studies of human patients.[9,19–21] One of the major goals of nutritional support is to improve outcome by preventing or minimizing deterioration in nutritional status, and this benefit has been demonstrated in a number of studies of human patient.[14–18] Determining the efficacy of PPN in dogs and cats is beyond the scope of this retrospective study. However, in this population of patients, survival rates were 69% in dogs and 81% in cats, with an overall survival rate of 73%. Our results are comparable with those of previous studies of dogs and cats receiving TPN, in which survival ranged from 51 to 70%.[7,8] Nutritional status of dogs and cats is difficult to quantify and direct comparisons between these populations of patients is difficult. However, survival is more likely related to underlying disease and severity of illness rather than to the type of nutritional support administered. Significantly more animals receiving any supplemental enteral nutrition in the current study survived compared to those not receiving any enteral nutrition. This finding could be related to direct benefits of enteral nutrition or to increased calorie intake provided by enteral nutrition, or could be a reflection of the severity of illness in patients fed enterally. Animals that tolerate enteral feedings may have been less severely ill and therefore may have experienced better survival. We found no evidence of an association between other factors and outcome. However, the power of the study may have been inadequate to show a difference even if one was present.

With growing recognition that patients that are not yet severely malnourished or debilitated may benefit from nutritional support, the use of PPN in the care of dogs and cats is increasing. In this study, we evaluated dogs and cats that received PPN as part of their therapeutic regimen. In a selected population of nondebilitated patients, PPN can be administered for short-term support with few serious complications. Most patients in this study returned to adequate oral intake within a few days of therapy and were successfully discharged from the hospital. Future studies are needed to evaluate the efficacy of PPN in preserving the nutritional status of dogs and cats and to explore potential benefits of PPN in the treatment of critically ill patients.

Footnotes

Acknowledgment

References

1. Zsombor-Murray E, Freeman LM. Peripheral parenteral nutrition. Compend Cont Educ Pract Vet 1999;21:512–523.

2. Marks SL. Enteral and parenteral nutritional support. In: Ettinger SJ, ed. Textbook of Veterinary Internal Medicine, 5th ed. Philadelphia, PA: WB Saunders; 2000:275–283.

3. Waddell LS, Michel KE. Critical care nutrition: Routes of feeding. Clin Tech Small Anim Pract 1998;13:197–203.

4. Lippert AC. The metabolic response to injury: Enteral and parenteral nutritional support. In: Murtaugh RJ, Kaplan PM, eds. Veterinary Emergency and Critical Care Medicine. Boston, MA: Mosby; 1992:593–617.

5. Mauldin GE, Reynolds AJ, Maudin GN, Kallfelz FA. Nitrogen

balance in clinically normal dogs receiving parenteral nutrition solutions. Am J Vet Res 2001;62:912–920.

6. Thatcher CD. Nutritional needs of critically ill patients. Compend Cont Educ Pract Vet 1996;18:1303–1311.

7. Lippert AC, Fulton RB, Parr AM. A retrospective study of the use of total parenteral nutrition in dogs and cats. J Vet Intern Med 1993;7:52–64.

8. Reuter JD, Marks SL, Rogers QR, Farver TB. Use of total parenteral nutrition in dogs: 209 cases (1998–1995). J Vet Emerg Crit Care 1998;8:201–213.

9. Barton RG. Nutrition support in critical illness. Nutr Clin Pract 1994;9:127–139.

10. Chandler ML, Guilford WG, Payne-James J. Use of peripheral parenteral nutritional support in dogs and cats. J Am Vet Med Assoc 2000;216:669–673.

11. McCowen KC, Malhotra A, Bistrian BR. Stress-induced hyperglycemia. Crit Care Clin 200;17:107–124.

12. Patino JF, Pimiento SE, Vergara A, et al. Hypocaloric support in the critically ill. World J Surg 1999;23:553–559.

13. McCowen KC, Friel C, Sternberg J, et al. Hypocaloric total parenteral nutrition: Effectiveness in prevention of hyperglycemia and infectious complications. A randomized, clinical trial. Crit Care Med 2000;28:3606–3611.

14. Schroeder D, Gillanders L, Mahr K, Hill GL. Effects of immediate postoperative enteral nutrition on body composition, muscle function, and wound healing. J Parenter Enter Nutr 1991;15:376–383.

15. Moore FA, Feliciano DV, Andrassy RJ, et al. Early enteral feeding, compared with parenteral reduces postoperative septic complications: The results of a meta-analysis. Ann Surg 1992;216:172–183.

16. Beier-Holgersen R, Boesby S. Influence of postoperative enteral nutrition on post-surgical infection. Gut 1996;39:833–835.

17. Beattie AH, Prach AT, Baxter JP, Pennington CR. A randomized controlled trial evaluating the use of enteral nutritional supplements postoperative in malnourished surgical patients. Gut 2000;46:813–818.

18. Keele AM, Bray M, Emery P, et al. Two phased randomized controlled clinical trial of postoperative dietary supplements in surgical patients. Gut 1997;40:393–399.

19. Giner M, Laviano A, Meguid MM, Gleason JR. In 1995 a correlation between malnutrition and poor outcome in critically ill patients still exists. Nutrition 1996;12:23–29.

20. von Meyenfeldt MF, Meijerink WJ, Rouflard MJ, et al. Perioperative nutritional support—A randomized clinical trial. Clin Nutr 1992;11:180–186.

21. Corish CA, Kennedy NP. Protein-energy undernutrition in hospital in-patients. Br J Nutr 2000;83:575–591.