Evaluation of dietary patterns in dogs with cardiac disease

Lisa M. Freeman, DVM, PhD, DACVN; John E. Rush, DVM, MS, DACVIM, DACVECC; Alane K. Cahalane, MA; Paul M. Kaplan, DVM, DACVIM; Peter J. Markwell, BVetMed

Objective—To determine the dietary patterns and intake of nutrients of concern in dogs with cardiac disease.

Design—Prospective study.

Animals—82 dogs with dilated cardiomyopathy (DCM) or chronic valvular disease.

Procedure—Owners of dogs were contacted and given a standardized telephone questionnaire regarding diet and a 24-hour food recall to determine daily intake of calories, protein, fat, sodium, potassium, and magnesium.

Results—Among the 82 dogs, 71% had no congestive heart failure (CHF), and 29% had CHF or a history of CHF. Sixty-one percent of dogs had concurrent diseases. Anorexia was or had been evident in 34% of dogs and was significantly more common in the CHF group and in dogs with DCM. Most dogs (92%) received some treats and table food, with a median percentage of daily calories from treats of 19% (range, 0% to 100%). Most owners (57%) that administered pills used human or pet foods for pill administration. Most dogs ate more than the Association of American Feed Control Officials (AAFCO) minimum values for fat and protein. Daily sodium intake varied from 14 to 384 mg/100 kcal, compared with the AAFCO minimum of 17 mg/100 kcal. A median of 25% of total daily sodium came from treats and table food (range, 0% to 100%). Dogs with CHF ate significantly more sodium, compared with dogs with no CHF.

Conclusions and Clinical Relevance—Dietary intake for dogs with cardiac disease is highly variable and often not optimal. (*J Am Vet Med Assoc* 2003;223:1301–1305)

Nutrition can play an important role in the management of patients with cardiac disease. Diet is involved in the pathogenesis of certain cardiac diseases (eg, taurine deficiency-induced **dilated cardiomyopathy [DCM]**) and changes in nutritional status are often found in animals with cardiac disease. Nutritional alterations in dogs with cardiac disease can include anorexia; cardiac cachexia; altered sodium, chloride, and potassium excretion; and nutrient deficiencies.[1-5] These alterations are often secondary to the disease and its treatment but may be caused by diet, concurrent conditions, or preexisting nutritional problems (eg, obesity). Anorexia is a common problem in cardiac disease and has been reported to occur in up to 84% of dogs with **congestive heart failure (CHF)**.[1] In addition, anorexia is a contributing factor in the decision for euthanasia in 68% of dogs with CHF.[1] The population in that study, however, was dogs with advanced cardiac disease, and the prevalence of anorexia in a less severely affected population of dogs with cardiac disease has not been reported.

In addition to the nutritional alterations that are often found in dogs with cardiac disease, nutritional modulation may slow progression of cardiac disease and improve quality of life. Nutritional modifications suggested for the management of cardiac disease have included sodium restriction, caloric supplementation, and administration of nutritional supplements (eg, taurine, L-carnitine, coenzyme Q10, and n-3 polyunsaturated fatty acids).[3-8] To prove benefits of these and other forms of nutritional modulation, randomized, double-blind, placebo-controlled studies are needed. One of the difficulties with such studies, however, is that the usual dietary patterns of dogs with cardiac disease are not known. For example, dietary patterns may change when the diagnosis of cardiac disease is made or with increasing severity of disease. In addition, dogs with cardiac disease are typically older and may have concurrent diseases that could also require dietary modifications. Finally, knowledge of the extent of use of treats and nutritional supplements would also be important in designing nutritional studies and dietary modification. The purpose of the study reported here was to determine the dietary patterns and prevalence of anorexia in dogs with cardiac disease and assess the intake of certain nutrients of concern for dogs with cardiac disease, including calories, protein, fat, sodium, potassium, and magnesium.

Materials and Methods

Dogs eligible for the study were identified from the cardiology database at the Foster Hospital for Small Animals or at referring veterinary hospitals by 1 of the coauthors (PMK). Dogs with either DCM or **chronic valvular disease (CVD)**, as diagnosed via echocardiography performed by a board-certified cardiologist, were eligible. Only dogs in which these diagnoses were made from January 1999 through November 2001 were selected so that the longest duration between diagnosis and administration of the questionnaire (June through December 2001) would be 18 months. To avoid new cases in which the dog might be medically unstable, the diag-

From the Department of Clinical Sciences, School of Veterinary Medicine, Tufts University, North Grafton, MA 01536 (Freeman, Rush, Cahalane); New England Veterinary Specialists, 174 Scribner Rd, Tyngsboro, MA 01886 (Kaplan); and WALTHAM Centre for Pet Nutrition, Waltham-on-the-Wolds, Melton Mowbray, Leicestershire, LE14 4RT, England (Markwell). Dr. Cahalane's present address is the Department of Clinical Sciences, College of Veterinary Medicine, Cornell University, Ithaca, NY 14853.

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Address correspondence to Dr. Freeman.

nosis had to be established at least 1 month prior to participation in the study. Dogs with CHF or a history of CHF documented by the attending cardiologist were subcategorized in the CHF group, whereas dogs without a history of CHF were subcategorized in the No CHF group.

Owners of all eligible dogs were contacted by telephone and given a standardized questionnaire that included questions on the dogs' concurrent diseases, medication use, diet history, and anorexia.[a] For the purposes of this study, anorexia was defined as a partial or complete loss of appetite. A 24-hour food recall was performed to determine all food intake over the last 24 hours. Owners were asked open-ended questions about all the foods the dog ate during the last 24 hours for each meal and snacks. Foods were categorized into several groups: dry dog food, canned dog food, homemade diet recipe, dog treats, table scraps, nutritional supplements, foods used to administer medications, and any other sources of food. Specific brands, flavors, sizes, and amounts were determined for each food. The entire telephone questionnaire typically ranged from 10 to 30 minutes in duration. Nutrient intake of calories, protein, fat, sodium, potassium, and magnesium was determined by use of the 24-hour food recall and manufacturer's information for commercial pet foods and pet treats. Nutritional information for other foods was obtained from the USDA Nutrient Database for Standard Reference, USDA/Agricultural Research Service Nutrient Data Laboratory. Intake of each nutrient was determined in total grams (or milligrams) per day, in grams (or milligrams) per kilogram of body weight, and in g (or mg)/100 kcal. Both the grams per kilogram and g/100 kcal help to account for variation in body weights, but the g/100 kcal basis also accounts for differences in caloric intake and allows comparison with the minimum nutrient levels for dogs.

χ^2 Analysis was used to determine differences in categoric variables between dogs with DCM and CVD, Tufts University cases and those of referring veterinarians, and dogs with clinical signs and those without such signs. Continuous variables were compared by use of independent *t* tests. All statistical analysis was performed with a commercial statistical software package.[b] A value of $P < 0.05$ was considered significant.

Results

The owners of 104 eligible dogs were contacted. Nineteen dogs had died, 2 owners declined to participate, and 1 owner provided conflicting answers and was excluded; thus, 82 dogs with cardiac disease were included in the study. Of these 82 dogs, 68 had CVD, and 14 had DCM. Mean age was 10.8 ± 2.8 years. Dogs with CVD (11.3 ± 2.6 years) were significantly older than dogs with DCM (8.3 ± 2.6; $P = 0.001$). Forty-four dogs were male (37 neutered), and 38 were female (37 neutered). There was no difference in sex distribution between CVD and DCM groups. The most common breed was Poodle (n = 11 [Toy, 4; Miniature, 6; Standard, 1]). Other common breeds included Dachshund (n = 8), Cavalier King Charles spaniel (6), mixed breed (6), Doberman Pinscher (5), Chihuahua (3), Keeshond (3), Yorkshire Terrier (3), Basset Hound (3), and Golden Retriever (3). Nineteen other breeds were represented. Median body weight was 10.9 kg (24.0 lb; range, 2.4 to 83.2 kg [5.3 to 183.0 lb]). Dogs with DCM (median weight, 37.5 kg [82.5 lb]; range, 13.7 to 83.2 kg [30.1 to 183.0 lb]) weighed significantly ($P < 0.001$) more than dogs with CVD (median weight, 9.1 kg [20.0 lb]; range, 2.4 to 44.1 kg [5.3 to 97.0 lb]). Body condition scores were available for 54 of 82 dogs, and mean body score was 5 ± 1. Most dogs (n = 46 [85%]) had a body condition score between 4 and 6 (on a scale of 1 to 9 in which 1 is emaciated, 5 is ideal, and 9 is obese, as recorded in the medical record).

Most dogs had no history of CHF (No CHF group, n = 58; CHF group, 24). Sixty-two dogs were receiving cardiac medications. The most commonly used medications included angiotensin converting enzyme inhibitors (n = 60 dogs), furosemide (24), β blockers (16), digoxin (10), and hydrochlorothiazide-spironolactone (6). Many dogs (n = 50 [61%]) had concurrent diseases including cancer (9), osteoarthritis (7), seizures (6), hypertension (6), urolithiasis (4), periodontal disease (4), collapsing trachea (3), chronic renal failure (3), and hyperadrenocorticism (3). Some dogs had multiple concurrent diseases.

Dogs that were patients at Tufts Foster Hospital for Small Animals (n = 69) were compared with those that were patients of referring veterinarians (13). There was no significant difference between these groups in age, sex, medications, number of dogs with clinical signs, number with DCM or CVD, or number with concurrent diseases.

Twenty-seven (33%) owners changed their dogs' diets when cardiac disease was first diagnosed, usually on the basis of the attending veterinarian's recommendation. Another 21 owners changed the diets later during the course of disease. Anorexia was a problem at the time of the telephone questionnaire or had been a problem at some point since the time of diagnosis in 28 dogs (34%). Anorexia was significantly ($P = 0.01$) more likely in the CHF group (13/24), compared with the No CHF group (15/58), and in dogs with DCM (9/14), compared with those with CVD (19/68 [$P = 0.009$]).

Various diets were eaten. The primary diets were commercial dry dog food (n = 32), commercial canned food (14), or both (29). Seven dogs consumed homemade diets exclusively, although none of these diets were nutritionally balanced formulas. There was no difference in diet type between dogs with DCM and CVD or between CHF and No CHF groups. Twenty-seven dogs were eating therapeutic diets, although only 4 were eating a diet designed specifically for cardiac disease. Other diets were fed for concurrent diseases (eg, reduced protein and phosphorus diets for renal disease, low fat diets for gastrointestinal disease, or novel ingredient diets for food allergies). Seventy-five of the 82 (92%) dogs received treats and table food. These included commercial dog treats (n = 55) and human food (52). Dogs received a median of 19% of their total daily calories from treats and table food, but this percentage ranged from 0 to 100% (**Table 1**). Nutritional supplements were given to 25 dogs (31%). Nutritional supplementation was more common in the DCM group, compared with the CVD group ($P = 0.006$). The most commonly administered nutritional supplements were multivitamin supplements (n = 8), coenzyme Q10 (7), L-carnitine (6), taurine (5), fish oil (5), and glucosamine (5).

Of the 69 dogs that received either medications or nutritional supplements, 39 (57%) were given pills in

Table 1—Dietary intake (median [range]) of nutrients of concern for 82 dogs with cardiac disease

Variable	All dogs	No CHF	CHF	RDVM	Tufts	DCM	CVD
No. of dogs	82	58	24	13	69	14	68
Body weight (kg)	10.9 (2.4–83.2)	12.7 (2.6–83.2)	8.1 (2.4–57.8)	9.9 (4.6–38.6)	11.6 (2.4–83.2)	37.5 (13.7–83.2)	9.1 (2.4–44.1)*
Calories (total kcal/d)	679 (102–2,660)	730 (102–2,660)	439 (142–1,912)	589 (273–2,628)	712 (102–2,660)	1,551 (686–2,660)	572* (102–2,628)
Calories (kcal/kg body weight)	53 (9–230)	50 (12–158)	54 (9–230)	63 (30–158)	48 (9–230)	37 (24–54)	56* (9–230)
Calories from treats (% total kcal)	19 (0–100)	17 (0–100)	29 (1–100)	13 (0–45)	27† (0–100)	24 (1–100)	18 (0–100)
Protein (total g/d)	43.6 (4.7–202.2)	44.0 (4.7–173.5)	37.7 (12.9–202.2)	32.9 (10.0–77.0)	44.3 (4.7–202.2)	87.7 (30.7–202.2)	40.1* (4.7–166.5)
Protein (g/kg body weight)	3.1 (0.7–19.1)	2.8 (0.7–8.8)	3.9‡ (1.1–19.1)	3.2 (1.1–5.6)	3.1 (0.7–19.1)	2.5 (0.7–3.6)	3.7* (0.7–19.1)
Protein (g/100 kcal)	6.2 (2.3–18.8)	6.1 (2.3–18.8)	7.2‡ (4.5–16.8)	4.5 (2.9–7.6)	6.6† (2.3–18.8)	6.1 (2.7–10.9)	6.3 (2.3–18.8)
Fat (total g/d)	26.2 (0.5–126.2)	27.0 (0.5–104.9)	21.1 (6.3–126.2)	23.4 (14.0–68.0)	27.0 (0.5–126.2)	53.9 (17.9–126.2)	21.9* (0.5–104.9)
Fat (g/kg body weight)	2.0 (0.1–9.2)	1.8 (0.1–6.9)	2.2 (0.5–9.2)	2.2 (1.0–5.1)	1.9 (0.1–9.2)	1.4 (0.7–2.4)	2.2* (0.1–9.2)
Fat (g/100 kcal)	3.8 (0.3–11.5)	3.7 (0.3–7.0)	3.8 (2.6–11.5)	3.7 (1.6–6.3)	3.8 (0.3–11.5)	3.7 (2.6–6.8)	3.8 (0.3–11.5)
Sodium (total mg/d)	538 (81–3,601)	538 (81–3,601)	570 (111–3,230)	344 (180–1,379)	720 (81–3,601)	1124 (180–3,601)	493* (81–3,230)
Sodium (mg/kg body weight)	45 (5–430)	41 (5–183)	51‡ (14–430)	35 (5–116)	46 (8–430)	35 (5–60)	48* (8–430)
Sodium (mg/100 kcal)	90 (14–384)	74 (14–252)	96‡ (37–384)	62 (14–171)	97† (35–384)	90 (14–163)	90 (25–384)
Sodium (% from treats)	25 (0–100)	23 (0–100)	34 (0–100)	16 (0–83)	25 (0–100)	28 (1–100)	24 (0–100)
Potassium (total mg/d)	1,135 (68–5,219)	1,153 (68–5,219)	984 (253–4,247)	856 (243–2,626)	1,156 (68–5,219)	2,367 (1,139–5,219)	1,043* (68–4,922)
Potassium (mg/kg body weight)	84 (9–541)	80 (9–541)	92 (26–532)	88 (52–158)	83 (9–541)	71 (28–107)	90* (9–541)
Potassium (mg/100 kcal)	175 (37–443)	168 (37–443)	195 (79–279)	145 (89–190)	182† (37–443)	171 (104–228)	176 (37–443)
Magnesium (total mg/d)	179 (9–2,475)	202 (9–2,475)	135 (37–860)	206 (83–450)	174 (9–2,475)	395 (136–2,475)	159* (9–1,111)
Magnesium (mg/kg body weight)	14 (3–54)	14 (3–52)	16 (6–54)	17 (6–52)	14 (3–54)	12 (3–30)	15 (3–54)
Magnesium (mg/100 kcal)	26 (8–122)	27 (8–122)	26 (15–59)	28 (17–57)	26 (8–122)	33 (12–122)	26 (8–115)

*Significant ($P < 0.05$) difference between dogs with dilated cardiomyopathy (DCM) and those with chronic valvular disease (CVD). †Significant ($P < 0.05$) difference between dogs examined by a referring veterinarian (RDVM) and those examined at Tufts Hospital for Small Animals (Tufts). ‡Significant ($P < 0.05$) difference between dogs with no congestive heart failure (No CHF) and dogs with current or past CHF.

human or pet foods. These included human foods (n = 34), canned dog food (4), and canned cat food (1). Many of the human foods were high-sodium foods such as lunch meats, bread, or cheese.

Dietary intake of calories, protein, fat, sodium, potassium, and magnesium was compared between CHF and No CHF groups, as well as dogs with DCM and CVD (Table 1). Dogs in the CHF group ate more sodium per kilogram ($P = 0.05$) and per 100 kcal ($P = 0.04$), compared with the No CHF group. Dogs in the CHF group also had a higher protein intake per kilogram ($P = 0.02$) and per 100 kcal ($P = 0.002$) than the No CHF group. Dogs with CVD ate more calories ($P < 0.001$), protein ($P = 0.003$), fat ($P = 0.01$), sodium ($P = 0.02$), and potassium ($P = 0.04$) per kilogram than dogs with DCM. These differences were not present when comparing the 2 groups on a per 100 kcal basis. There was wide variation in nutrient intake for all

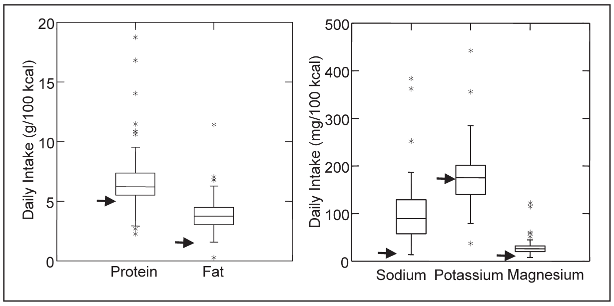

Figure 1—Daily intake of macronutrients (protein and fat; left panel) and micronutrients (sodium, potassium, and magnesium; right panel) for 82 dogs with chronic valvular disease (n = 68) or dilated cardiomyopathy (14). Each box represents the central 50% of the values. The horizontal line in each box represents the median value and whiskers indicate the range (± 1.5 X interquartile range). Asterisks represent outliers. Arrows indicate the minimum value for each nutrient as established by the Association of American Feed Control Officials.

groups. Dogs that were treated at Tufts Foster Hospital for Small Animals were compared with those that were treated by referring veterinarians. Tufts' dogs received a greater proportion of their calories from treats ($P = 0.006$) and ate more sodium ($P = 0.03$), potassium ($P = 0.02$), and protein ($P = 0.001$) on a per 100 kcal basis, compared with referring veterinarians' dogs.

When daily intake of the measured macronutrients (ie, protein and fat) and micronutrients (ie, sodium, potassium, and magnesium) was compared with the **Association of American Feed Control Officials (AAFCO)** minimum values, variability of the nutrient intake was also evident **(Fig 1)**.[9] Most dogs ate more than the AAFCO minimum value for fat (1.4 g/100 kcal) and protein (5.1 g/100 kcal), although 16 (20%) dogs had a daily protein intake below the AAFCO minimum. For sodium, all dogs except 1 had a daily intake above the AAFCO minimum (17 mg/100 kcal). For potassium, the median daily intake was approximately at the AAFCO minimum value (170 mg/100 kcal), and 49% of dogs had a potassium intake less than the minimum value. All dogs except 5 had a daily magnesium greater than the AAFCO minimum value (11 mg/100 kcal).

Discussion

Nutrients of concern in cardiac disease will depend to a certain degree on the individual animal but in general are considered to be calories, protein, fat, sodium, potassium, and magnesium. The nutrient intake of dogs in this study was extremely variable. Although most dogs ate more than the AAFCO minimum values for fat and protein, 20% of dogs ate less protein than the AAFCO minimum value. Because loss of lean body mass is an important issue in dogs with cardiac disease, adequate protein intake should be maintained.[3] Because 99% of the dogs in this study had daily sodium intake greater than the AAFCO minimum value, inadequate sodium intake does not appear to be an issue. However, many of the dogs had extremely high sodium intakes (the highest was 384 mg/100 kcal or 23 times the AAFCO minimum value). On a per kilogram basis, sodium intakes were as high as 430 mg/kg. Although the optimal daily dose of sodium has not been established for dogs with cardiac disease, in humans sodium is typically restricted to 2 g of sodium/d (or 29 mg/kg for a 70-kg person).[10] The degree of sodium restriction will vary depending upon the individual patient, but results of our study suggest that most dogs with cardiac disease are receiving sodium far in excess of their needs, and this may affect medical treatment for dogs with CHF.

Results were more variable for potassium for which 49% of dogs ate less potassium than the AAFCO minimum value and 51% ate more. Potassium requirements may vary, depending upon the severity of disease, diuretic type and dose, angiotensin converting enzyme inhibitor use, and concurrent diseases. Diuretics such as furosemide can increase potassium excretion, whereas angiotensin converting enzyme inhibitors and potassium-sparing diuretics can lead to potassium retention. Therefore, attention to serum and dietary potassium is warranted. Nearly all dogs in the study had a daily magnesium greater than the AAFCO minimum. Similar to potassium, magnesium requirements may vary, depending on medical treatment. Because magnesium deficiency has been reported to occur in dogs with CHF and can contribute to arrhythmogenesis, monitoring of magnesium status is useful in dogs with cardiac disease.[11] Commercial dog foods vary in magnesium content, so adjustment may be warranted for some dogs.

Although most authors discuss dietary recommendations for dogs with cardiac disease, only 4 dogs in this study were eating therapeutic diets designed for dogs with cardiac disease.[4,6-8,12] This may be because specific cardiac diets are not being recommended, poor owner-dog acceptance of the diets, or dogs are eating other diets as the result of concurrent diseases.

Although it is not surprising, most dogs (92%) were receiving treats or table food. No studies have been performed to determine the maximum amount of treats that should be in the optimal canine diet, but general recommendations are for < 10% of the total calories to come from treats to avoid an unbalanced diet. In our study, 71% of dogs were consuming > 10% of their total daily calories from treats and table food. Even more of an issue, however, was that many of the foods used as treats were high in sodium and other nutrients that are of concern in dogs with cardiac disease. The median total daily intake of sodium from treats and table foods was 25%, but this was highly variable among dogs.

Even more striking was the sodium content of foods used to administer medications. In some dogs receiving a large number of pills per day (which could be either cardiac medications or nutritional supplements), this food could make a major contribution to the daily diet. In addition, most of the foods used for pill administration are high-sodium foods such as bread, lunch meats, peanut butter, and cheese. Most owners are not aware of the sodium content of most table food. Even if they are feeding dogs a low sodium dog food, they may be contributing large amounts of sodium to the diet via treats and foods used to administer pills.

Nutritional supplements were being administered to 31% of the dogs in this study and more commonly administered to dogs with DCM. Efficacy has not been established for most nutritional supplements. Some commercial dog foods are now including nutritional supplements proposed to be of benefit for cardiovascular disease such as antioxidants, carnitine, and taurine, so additional supplementation may or may not be beneficial. In addition, nutritional supplements may interact with cardiac medications, so it is important to specifically ask owners about supplements they are administering to their dogs.

Cardiac disease is most common in older dogs, so the finding that 61% of dogs in this study had concurrent diseases is not surprising. However, it does support the concept that the optimal diet for a dog with cardiac disease must be individualized to match the dog's clinical signs, laboratory values, and concurrent diseases.

Anorexia was a current or past problem in 34% of the dogs in our study. For the purposes of the study, anorexia was defined as a partial or complete loss of appetite. Partial loss of appetite was included in the definition because, in the authors' experience, reduction in appetite or changes in food preferences are a common problem in dogs with cardiac disease. Because the owner was required to list the occurrence of anorexia from memory, some dogs that had anorexia were probably not reported in the questionnaire. Conversely, dogs that may have been anorectic for reasons other than cardiac disease might also have been included, because the owner may not have been able to determine the cause of the anorexia. This might have been true for the dogs without clinical signs that had anorexia (26%), although it is also possible that those dogs developed changes in appetite before other signs of cardiac disease were apparent. Nonetheless, the common occurrence of anorexia, particularly in the CHF group and dogs with DCM, is an important finding because it may negatively affect quality of life and is a common contributing factor to the euthanasia decision.

There were a number of limitations to our study. The information from owners on diet history and anorexia was dependent on the owners' memories. In addition, we chose to use a 24-hour recall to assess dietary intake. A variety of dietary assessment techniques are used in humans, and each has its advantages and disadvantages. We chose the 24-hour recall because it is easy to perform for the interviewer and the owner, which resulted in a reasonable number of dog owners agreeing to participate in the study. The 24-hour recall also has more objectivity than diet history, good repeatability, and good reliability between interviewers.[13] However, a single 24-hour period may not be representative of an individual's diet because of variations in consumption from day to day. In addition, low nutrient intakes are often overreported, and high intakes are often underreported. Nonetheless, 24-hour recalls can provide reliable group mean intakes.[13]

Although further studies are needed to determine whether the dietary information collected in our study is applicable to other patient populations, our results may be useful for establishing baseline information for intervention studies. These results also provide information about areas in which nutritional modifications might be beneficial for dogs with cardiac disease (eg, supplying additional protein for certain dogs or reducing sodium intake). In addition, there are a number of areas in which additional client education about diet would be useful, such as the use of treats and foods used to administer medications.

[a]The questionnaire and 24-hour recall questions are available from the corresponding author on request.
[b]Systat 9.01, SPSS, Chicago, Ill.

References

1. Mallery KF, Freeman LM, Harpster NK, et al. Factors contributing to the decision for euthanasia in dogs with congestive heart failure. *J Am Vet Med Assoc* 1999;214:1201–1204.

2. Rush JE, Freeman LM, Brown DJ, et al. Clinical, echocardiographic, and neurohormonal effects of a low sodium diet in dogs with heart failure. *J Vet Intern Med* 2000;14:513–520.

3. Freeman LM, Rush JE, Kehayias JJ, et al. Nutritional alterations and the effect of fish oil supplementation in dogs with heart failure. *J Vet Intern Med* 1998;12:440–448.

4. Roudebush P, Keene BW, Mizelle HL. Cardiovascular disease. In: Hand HS, Thatcher CD, Remillard RL, et al, eds. *Small animal clinical nutrition.* 4th ed. Marceline, Mo: Walsworth Publishing Co, 2000;529–562.

5. Kittleson MD, Keene B, Pion PD, et al. Results of the Multicenter Spaniel Trial (MUST): taurine- and carnitine-responsive dilated cardiomyopathy in American Cocker Spaniels with decreased plasma taurine concentration. *J Vet Intern Med* 1997;11:204–211.

6. Ettinger SJ. Dietary modifications in cardiac disease. In: Ettinger SJ, Feldman EC, eds. *Textbook of veterinary internal medicine.* 5th ed. Philadelphia: WB Saunders Co, 2000;262–269.

7. Roudebush P, Freeman LM. Nutritional management of heart disease. In: Bonagura JD, ed. *Current veterinary therapy XIII.* Philadelphia: WB Saunders Co, 2000;711–716.

8. Goodwin J, Strickland KN. The role of dietary modification and nondrug therapy in dogs and cats with congestive heart failure. *Vet Med* 1998;93:919–926.

9. Association of American Feed Control Officials. *Official publication.* Oxford, Ind: Association of American Feed Control Officials, 2002;139–140.

10. American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *ACC/AHA guidelines for the evaluation and management of chronic heart failure in the adult.* Available at: www.acc.org/clinical/guidelines/failure/hf_index.htm.

11. Cobb M, Michell AR. Plasma electrolyte concentrations in dogs receiving diuretic therapy for cardiac failure. *J Small Anim Pract* 1992;33:526–529.

12. Freeman LM. Interventional nutrition for cardiac disease. *Clin Tech Small Anim Pract* 1998;13:232–237.

13. Dwyer J. Dietary assessment. In: Shils ME, Olson JA, Shike M, et al, eds. *Modern nutrition in health and disease.* 9th ed. Baltimore: The Williams & Wilkins Co, 1999;937–959.