Relationship Between Circulating and Dietary Taurine Concentrations in Dogs with Dilated Cardiomyopathy

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ABSTRACT

A retrospective study was conducted to determine dietary taurine concentrations in dogs with dilated cardiomyopathy (DCM) and to compare the clinical outcome of taurine-deficient and non–taurine-deficient dogs. Taurine concentrations were low in blood samples from 20 of 37 dogs with DCM. Median dietary taurine concentration was not significantly different between taurine-deficient and nondeficient dogs. There was no correlation between dietary and circulating taurine concentrations. The outcome of taurine-deficient dogs supplemented with taurine was not different from the outcome of nondeficient dogs. The role of taurine and its relationship to dietary intake in canine DCM remain unclear.

INTRODUCTION

Taurine is an amino acid that is essential for normal cardiac, immune, retinal, platelet, and reproductive functions.[1] The function of taurine in calcium homeostasis as well as its high concentrations in the myocardium underscore its importance in cardiac function. The role of taurine deficiency in feline dilated cardiomyopathy (DCM) has been well described.[2–5] Because of the increased taurine supplementation of commercial cat foods in the late 1980s, there has been a dramatic decline in the incidence of feline DCM. The few cases of feline DCM still seen are predominantly either taurine independent or are the result of cats being fed unconventional diets.

Unlike the situation in cats, taurine is not an essential amino acid in dogs.[1] The association between taurine and feline DCM, however, has prompted investigators to examine the role of taurine in canine DCM. Previous studies have shown that dogs with DCM that are of breeds that commonly develop this condition did not have low taurine concentrations, and taurine supplementation had no benefit on their cardiac

function.[5] Although taurine deficiency is not present in most dogs with DCM, low taurine concentrations have been found in certain breeds of dogs with the disease.[3] This has been best established in the American cocker spaniel.[3,4] In a recent study, 11 cocker spaniels showed improvement in clinical parameters and echocardiographic measurements when supplemented with taurine and carnitine.[4] Whether the response would be similar with single therapy is unknown. Dogs of several other breeds not usually affected by DCM also have been found to have low taurine concentrations in association with DCM, but the relationship between canine DCM and taurine is still unknown. Currently, measurements of plasma and whole-blood taurine concentrations are recommended for cocker spaniels or other breeds with DCM that are not usually affected with this condition.[4,5] Supplementation with taurine (500 mg) and carnitine (1 g), given orally two or three times daily, also has been recommended for dogs with documented taurine deficiency until additional research is done.[4,5]

The cause for low taurine concentrations in some dogs with DCM is unclear. Increased losses through the gastrointestinal or renal systems could account for low taurine concentrations, as could reduced taurine biosynthesis. Although dogs are thought to be able to synthesize adequate amounts of taurine, low or unavailable dietary concentrations might also decrease circulating concentrations. In addition, low taurine concentrations could be a secondary effect of the underlying disease. Myocardial carnitine concentrations, for example, are known to decrease in dogs that are experimentally induced to develop congestive heart failure (CHF) through rapid pacing.[6] Since dietary taurine has never been a concern for dogs because of their apparent lack of need for dietary intake of this amino acid, the relationship between dietary and circulating concentrations has not been examined.

The purpose of the current study was to determine dietary taurine concentrations in dogs with DCM and to determine the clinical outcome of taurine-deficient dogs supplemented with taurine.

MATERIALS AND METHODS

Test Subjects

All dogs having a diagnosis of DCM and having blood samples submitted to Tufts Veterinary Diagnostic Laboratory, North Grafton, MA between 1997 and 1999 were enrolled in this retrospective study. The medical record for each dog was reviewed using a standardized data sheet for information on signalment, physical examination, echocardiographic measurements, medical treatment, and outcome. For dogs that were not patients of Tufts University, information was collected by contacting the referring veterinarian. Although the exact cutoff for a definition of taurine deficiency is controversial, for the purposes of this study, dogs were classified as taurine deficient if the plasma taurine level was less than 45 nmol/ml or the whole-blood taurine level was less than 250 nmol/ml.[4,5]

Evaluations

Each dog's usual diet was determined from the medical record or by calling the owners. Dietary taurine concentration was determined from information provided by the manufacturer. The dogs' responses to therapy were assessed by survival time, change in cardiac dimensions (e.g., left atrium, left ventricular internal diameter [LVID], interventricular septum, left ventricular free wall [LVFW], and right ventricle), fractional shortening on echocardiography, the ability to reduce the number of medications, furosemide dosage, and the severity of heart failure as measured by the modified New York Heart Association (MNYHA) classification (Table 1).[7]

TABLE 1. Modified New York Heart Association Functional Classification[7]

Class	*Definition*
I	No limitation of physical activity. Ordinary physical activity does not cause undue fatigue or dyspnea.
II	Slight limitation of physical activity. Comfortable at rest, but ordinary physical activity results in fatigue or dyspnea.
III	Marked limitation of physical activity. Comfortable at rest, but less than ordinary activity causes fatigue or dyspnea.
IV	Unable to carry on any physical activity without symptoms. Symptoms are present even at rest. If any physical activity is undertaken, symptoms are increased.

Statistical Analysis

Categorical data were compared by chi-square analysis, while independent *t*-tests were used to compare continuous data. Paired *t*-tests were used to compare echocardiographic measurements before and after taurine supplementation within the taurine-deficient and the non–taurine-deficient groups.

RESULTS

Blood samples from 37 dogs were submitted for taurine analysis. Twenty-three dogs were male and 14 were female. The mean age was 8.5 ± 2.9 years. Twenty of the 37 dogs had taurine deficiency based on either plasma or whole-blood analysis and 17 dogs were considered to have adequate taurine levels. Fifteen of the 20 deficient dogs had low levels of taurine in both plasma and whole blood; however, one dog had low plasma levels only (whole blood was not tested); two dogs had low whole-blood levels only (plasma was not tested); and two dogs had low whole-blood levels with normal plasma levels. Taurine levels were not impacted by sex or age of the dog ($P > .05$). Eleven males and nine females were taurine deficient compared with 12 males and five females that were not deficient. Taurine-deficient dogs were 8.3 ± 3.1 years of age versus 8.6 ± 2.9 years for the nondeficient dogs. The most common breed for which blood was submitted for taurine analysis was the cocker spaniel (Table 2). Of the ten dogs of this breed with blood submitted for analysis, seven were taurine deficient. Other commonly represented breeds were golden retriever and Labrador retriever.

TABLE 2. Breed Distribution of Dogs Having Taurine Concentrations Determined in Whole-Blood Samples

Breed	*All Dogs*	*Taurine - deficient Dogs*
Cocker spaniel	10	7
Golden retriever	5	4
Labrador retriever	5	3
Dalmatian	3	0
St. Bernard	2	2
Rottweiler	2	1
Mixed breed	2	1
American bulldog	1	1
Collie	1	1
Mastiff	1	0
Border collie	1	0
Bulldog	1	0
Doberman	1	0
Springer spaniel	1	0
Irish setter	1	0
Total	37	20

Breed distribution between the taurine-deficient and nondeficient groups was not significantly different ($P = .18$). Median plasma concentration of taurine was 4.0 nmol/ml for the 18 taurine-deficient dogs and 112.0 nmol/ml for the 15 nondeficient dogs ($P < .001$) (Table 3). Median taurine concentration in whole-blood samples was 100.0 nmol/ml from 19 taurine-deficient dogs and 400.0 nmol/ml for 17 nondeficient dogs ($P < .001$) (Table 3).

Taurine content of the dogs' usual diets was also determined based on manufacturers' data. Dietary information was available for 34 dogs and dietary taurine could be determined for 28 of 37 dogs. In the deficient group, seven of the diets were lamb and rice based and seven had increased concentrations of fiber (three diets had both of these properties). In the nondeficient group, three of the diets were lamb and rice based and one diet had increased concentrations of fiber ($P = .07$ versus the taurine-deficient group). Median dietary taurine (dry-matter basis) was 300 ppm for the 18 taurine-deficient dogs and 285 ppm for the ten nondeficient dogs (Table 3). The difference was not significantly different ($P = .58$). There was no correlation between dietary taurine and circulating plasma ($r = .26$; $P = .20$) or whole-blood ($r = .32$; $P = .11$) taurine concentrations.

At the initial presentation, mean body weight, heart rate, and furosemide dosage were similar for the taurine-deficient and nondeficient dogs (Table 4). Dogs with taurine deficiency were more likely ($P = .01$) to be in CHF (8 of 20 dogs) than were nondeficient dogs (9 of 17 dogs), and taurine-deficient dogs had a higher ($P = .003$) MNYHA classification (3.7 ± 0.6 versus 2.5 ± 1.1) on presentation (Table 4). Echocardiographic measurements at initial presentation were not significantly different between dogs with low and normal taurine concentrations (Table 4).

Of the 20 dogs with taurine deficiency, two died in the hospital and one was lost to follow-up. Of the 17 that left the hospital and for which information was available, nine received taurine supplementation, six received taurine plus carnitine, and two received neither. All were treated with standard cardiac medications appropriate for their stage of disease and clinical signs. Medications (both in number of medications and in dosage) were not different between the two groups. Other medications administered included angiotensin-converting enzyme inhibitors (17 taurine-deficient and 16 nondeficient), digoxin (ten taurine-deficient and nine nondeficient), β-blockers (three taurine-deficient and four nondeficient), diltiazem (two nondeficient), spironolactone (one in each group), and spironolactone/hydrochloro-

TABLE 3. Taurine Levels in Whole Blood, Plasma, and Diets for Taurine-deficient and Nondeficient Dogs

Group	*Source*	*Number of Dogs*	*Median*	*Range*
Taurine-deficient Dogs	Plasma	18	4.0 nmol/ml	1.7–104.0 nmol/ml
	Whole blood	19	100.0 nmol/ml	2.0–245.0 nmol/ml
	Diet (dry-matter basis)	18	300 ppm	100–921 ppm
Nondeficient	Plasma	15	112.0 nmol/ml	57.1–344.1 nmol/ml
	Whole blood	17	400.0 nmol/ml	205.7–788.2 nmol/ml
	Diet (dry-matter basis)	10	285 ppm	150–1300 ppm

TABLE 4. Baseline Clinical and Echocardiographic Parameters for All Taurine-deficient and Nondeficient Dogs

Parameter	*Taurine-deficient Dogs (n=20)*	*Nondeficient Dogs (n=17)*
Weight (kg)	32 ± 21	35 ± 17
Heart rate (beats/min)	148 ± 32	144 ± 39
MNYHA class*	3.7 ± 0.6†	2.5 ± 1.1
Furosemide dosage (mg/kg/day)	4.7 ± 2.5	2.9 ± 3.1
Left ventricular internal diameter (diastole) (cm)	5.8 ± 1.3	5.7 ± 1.1
Left ventricular internal diameter (systole) (cm)	4.9 ± 1.3	4.8 ± 1.3
Aorta (cm)	2.2 ± 0.5	2.5 ± 0.5
Left atrium (cm)	3.4 ± 0.8	3.5 ± 0.7
Fractional shortening (%)	15.6 ± 10.0	17.1 ± 10.0

*MNYHA = Modified New York Heart Association (refer to Table 1 for class definitions).
†Significantly greater than non–taurine-deficient dogs ($P < .05$).

thiazide (three nondeficient). There was a trend ($P = .06$) for more dogs in the taurine-deficient group to also receive furosemide (n = 16) compared with the nondeficient group (n = 11). The median dosage of supplements for the 15 dogs receiving taurine or carnitine was 42.5 mg taurine/kg/day (range = 18.8 to 127.1 mg/kg/day) and 196.8 mg L-carnitine/kg/day (range = 147.1 to 392.2 mg/kg/day). Nine of the 17 nondeficient dogs received taurine supplementation on a short-term basis (i.e., until taurine concentrations were available), three received taurine supplementation long-term, and five received no taurine.

Of the 15 taurine-deficient dogs treated with taurine or carnitine and the 17 nondeficient dogs, ten in each group were given at least one follow-up evaluation; four dogs had multiple evaluations. Median time from initial presentation to the first follow-up evaluation was 117 days (range = 28 to 357 days). At the first follow-up evaluation, there was no difference in the number of medications that had been discontinued (five in the taurine-deficient and two in the nondeficient group) (Table 5). In addition, there was no difference between groups ($P = .10$) in the change in furosemide dosage (–2.8 ± 2.0 mg/kg/day in the taurine-deficient group versus –0.6 ± 3.5 mg/kg/day in the nondeficient group). The MNYHA classification was significantly reduced ($P = .007$) in the taurine-deficient group (–1.6 ± 0.8) compared with that for the nondeficient group (–0.3 ± 1.1), but this difference was no longer significant ($P > .05$) after correcting for the greater severity in the taurine-deficient group at baseline.

All ten dogs in the taurine-deficient group and seven of ten dogs in the nondeficient group had echocardiograms at the first reevaluation. Dogs in the taurine-deficient group had a significantly greater decrease ($P = .04$) in LVID in systole and a significantly greater increase ($P = .04$) in LVFW thickness in diastole compared with the nondeficient group (Table 5). There were no other echocardiographic differences between groups at the first reevaluation.

At their final evaluation, dogs in the taurine-deficient group had a significantly greater decrease in LVID in systole ($P = .03$) and a sig-