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Cardiovascular diseases: nutritional modulation

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Many scientific advances have improved our knowledge of cardiac disease and congestive heart failure (CHF) in dogs. In addition to new cardiac medications, recent advances have improved our understanding of nutritional interventions and nutritional pharmacology. Cardiovascular disease is still one of the most common life-threatening disorders in dogs. Most canine cardiac diseases cannot be cured and the disease process is typically progressive, leading to advanced CHF or lethal cardiac arrhythmias. Nutritional interventions for cardiac disease remain one of the mainstays of therapy and one of the more exciting avenues for further scientific investigation.

1 - Epidemiology

Many risk factors and clinical associations have been identified for cardiovascular disorders in dogs. Breed predispositions are recognized for most of the common cardiovascular diseases **(Table 1)**. Many small to medium sized dog breeds are predisposed to acquired chronic valvular disease (CVD; endocardiosis), while dilated cardiomyopathy (DCM) and pericardial disease are the most common causes of congestive heart failure (CHF) in large breed dogs.

Certain cardiovascular disorders are recognized to have a sex predisposition; for example, female dogs are predisposed to patent ductus arteriosus and male dogs are predisposed to CVD, idiopathic pericardial disease, and bacterial endocarditis.

Dogs with renal or adrenal disease can develop systemic hypertension and this can predispose or contribute to existing cardiac disease.

2 - Diagnosis of canine cardiac disease

Congenital and acquired cardiac diseases often lead to similar compensatory responses and neuroendocrine activation. Due to the similarities in response of the heart, systemic and pulmonary vasculature and the neuroendocrine systems, several common historical findings and clinical signs result from most of the canine cardiovascular diseases.

► Clinical signs

Common historical complaints include cough, shortness of breath, and syncope **(Table 2)**. Cardiac disease can be quite advanced when the owner is first able to detect clinical abnormality, however many cardiac diseases can be detected by the attending veterinarian well in advance of the development of clinical signs.

Most congenital cardiac diseases are accompanied by a loud cardiac murmur. The most common form of cardiovascular disease in the dog, CVD, typically has a cardiac murmur that can be readily identified well before outward clinical signs of cardiovascular disease are evident. The abnormalities that are most commonly identified on physical examination from dogs with cardiovascular disease are listed in **Table 3**.

TABLE 2 - COMMON HISTORICAL FINDINGS IN DOGS WITH CARDIOVASCULAR DISEASE

- Coughing
- Gagging
- Shortness of breath or difficulty breathing
- Inability to sleep comfortably through the night
- Fainting or "seizure" (syncope)
- Weight loss
- Abdominal distension
- Weakness
- Exercise intolerance
- Poor growth (congenital heart disease)

TABLE 3 - COMMON PHYSICAL EXAMINATION FINDINGS FROM DOGS WITH CARDIOVASCULAR DISEASE

Cardiac murmur	Dyspnea
Cardiac gallop	Pulmonary crackles
Cardiac arrhythmia	Ascites
Tachycardia	Abdominal organomegaly
Bradycardia	Cyanosis
Weak arterial pulses	Mucous membrane pallor
Pulsus paradoxus	Delayed capillary refill time (> 2 seconds)
Jugular vein distension	

TABLE 1 - BREED PREDISPOSITIONS FOR VARIOUS CARDIOVASCULAR DISEASES
(Compiled from Buchanan, 1992; Kittleson, 1998; Sisson, 2000b; and the computer database at Cummings School of Veterinary Medicine at Tufts University)

Breed	Cardiovascular disease predisposition	Breed	Cardiovascular disease predisposition
Airedale Terrier	PS	Keeshond	PDA, Tetralogy of Fallot, MVD
Akita	Pericardial disease	Kerry Blue Terrier	PDA
Basset Hound	PS	Labrador Retriever	TVD, PS, PDA, DCM, supraventricular tachycardia, pericardial disease
Beagle	PS, CVD	Maltese	PDA, CVD
Bichon Frisé	PDA, CVD	Mastiff	PS, MVD
Boston Terrier	CVD, HBT	Miniature Pinscher	CVD
Boxer	SAS, PS, ASD, Boxer cardiomyopathy, HBT, BE, vasovagal syncope	Miniature Schnauzer	PS, CVD, sick sinus syndrome
Boykin Spaniel	PS	Newfoundland	SAS, PS, DCM
Bull Terrier	MVD, acquired mitral and aortic fibrosis	Old English Sheepdog	DCM, atrial standstill
Cavalier King Charles Spaniel	CVD	Papillon	CVD
Chihuahua	PS, PDA, CVD	Pomeranian	PDA, sick sinus syndrome, CVD
Chow Chow	PS, CTD, VSD	Poodle (miniature and toy)	PDA, CVD
Cocker Spaniel	PDA, PS, CVD, DCM, sick sinus syndrome	Portuguese Water Dog	Juvenile DCM
Collie	PDA	Rottweiler	SAS, DCM, BE
Dalmatian	DCM	Saint Bernard	DCM
Dachshund	CVD	Samoyed	PS, ASD, SAS, VSD
Doberman Pinscher	ASD, DCM	Scottish Deerhound	DCM
English Bulldog	PS, SAS, VSD, MVD, Tetralogy of Fallot	Scottish Terrier	PS
English Springer Spaniel	VSD, PDA, atrial standstill	Shetland Sheepdog	PDA
Fox Terrier	PS, CVD	Terrier breeds	PS, CVD
German Shepherd	PDA, SAS, TVD, MVD, PRAA, juvenile ventricular arrhythmia, pericardial disease, DCM, BE	Weimaraner	TVD, peritoneopericardial diaphragmatic hernia
German Short-Haired Pointer	SAS, HCM, pericardial disease, BE	Welsh Corgi	PDA
Golden Retriever	SAS, MVD, TVD, DCM, pericardial disease, BE	West Highland White Terrier	PS, VSD, sick sinus syndrome, CVD
Great Dane	MVD, TVD, SAS, PRAA, DCM	Whippet	CVD
Irish Setter	PRAA, PDA	Yorkshire Terrier	PDA, CVD
Irish Wolfhound	DCM, atrial fibrillation		

Key: ASD = Atrial septal defect, BE = Bacterial endocarditis, CTD = Cor triatriatum dexter, CVD = Chronic valvular disease, DCM = Dilated cardiomyopathy, HBT = Heart base tumor, HCM = Hypertrophic cardiomyopathy, MVD = Mitral valve dysplasia PDA = Patent ductus arteriosus, PRAA = Persistent right aortic arch, PS = Pulmonic stenosis, SAS = Subaortic stenosis, TVD = tricuspid valve dysplasia, VSD = ventricular septal defect.

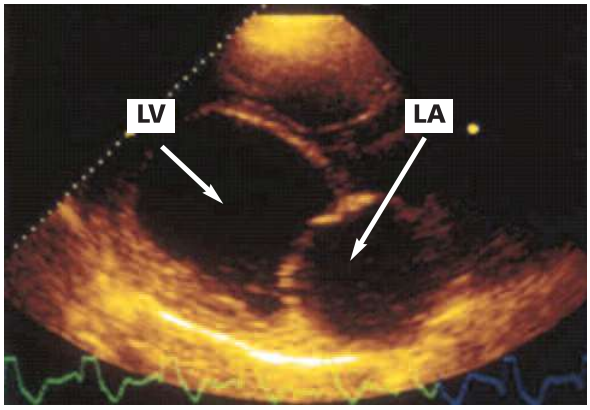
► Diagnostic tests

Once cardiovascular disease is established as a differential diagnosis, a battery of routine tests are often performed to confirm cardiovascular disease, establish the severity of disease, and permit an informed decision to be made regarding treatment.

An electrocardiogram should be performed in all dogs with evidence of cardiac arrhythmia, including those with arrhythmia noted on cardiac auscultation and those with femoral arterial pulse deficits, bradycardia, tachycardia, or a history of syncope, seizure, or collapse.

Thoracic radiographs are indicated to establish whether CHF is present and to help determine the degree of cardiac enlargement, the size of the pulmonary vessels, and the size of the caudal vena cava. Thoracic radiographs are the best diagnostic test to exclude respiratory diseases as either the cause or a contributor to the animal's clinical signs. For many cardiovascular diseases, echocardiography is the key diagnostic test to establish the exact cause of the disease. Echocardiography also facilitates the evaluation of cardiac chamber enlargement and permits quantitative evaluation of cardiac chamber size, wall thickness, and myocardial and valve function **(Figure 1)**.

FIGURE 1 - ECHOCARDIOGRAPHY INDICATING DILATED CARDIOMYOPATHY IN A BOXER



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Right parasternal long axis view showing the dilatation of the left atrium (LA) and left ventricule (LV).

In dogs with congenital disease, echocardiography is used to confirm the type of defect, establish the severity of the defect, and is an invaluable aid in offering therapeutic and prognostic advice. Echocardiography is a key tool for the diagnosis and management of cardiac disease and should be offered in all cases where serious cardiovascular disease is a differential diagnosis.

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Dilated cardiomyopathy may be associated with taurine deficiency in certain breeds, such as the Golden Retriever, the Newfoundland and the Cocker Spaniel.

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Many additional tests are useful in the diagnosis and management of dogs with cardiac disease.

- Heartworm (*Dirofilaria immitis*) antigen testing should be carried out in dogs from endemic areas.
- A complete blood count and biochemistry profile should be carried out to search for concurrent diseases and establish baseline values prior to therapy. Alterations in blood urea nitrogen, creatinine, and the serum electrolytes sodium, potassium, chloride and magnesium can develop following the initiation of various cardiac medications, and knowledge of these alterations is useful in selecting or altering the diet.
- Plasma and whole blood taurine levels may be indicated in dogs with evidence of reduced systolic function on echocardiography, especially in certain breeds of dogs (e.g. Cocker Spaniel, Golden Retriever, Newfoundland) and in dogs consuming certain diets (see below).
- Measurement of systemic blood pressure is useful to exclude systemic hypertension as a contributing factor to the cardiovascular disease. In addition, when hypotension develops following initiation of pharmacologic therapy, a baseline blood pressure measurement can be used for comparison.
- A variety of additional specialized cardiovascular tests, such as Holter monitor recorders, event monitor recorders, computed tomography, phonocardiography, and cardiac catheterization are available for specific clinical settings.

3 - Treatment of cardiac disease

It is beyond the scope of this chapter to mention the appropriate treatment for each cardiovascular disease recognized in dogs and the reader is referred to the many excellent textbooks on specific pharmacologic or surgical treatments (*Kittleson & Kienle, 1998; Fox et al, 1999; Kittleson, 2000; Sisson et al, 2000a; Ware & Keene, 2000)*. Common cardiovascular medications include furosemide, angiotensin converting enzyme (ACE) inhibitors, digoxin, positive inotropes, beta-blockers, antiarrhythmic drugs, and additional diuretics such as thiazide diuretics and aldosterone receptor blockers (eg, spironolactone). Medications used in an individual patient can impact appropriate diet selection (see below).

In general, dietary management of dogs with cardiac disease depends upon the clinical signs and stage of heart failure, rather than the underlying disorder. Therefore, the dietary management of a dog with CHF secondary to ventricular septal defect or bacterial endocarditis would be similar to that of a dog with CVD and CHF. When selecting a diet for a dog with cardiac disease, clinicians should take into consideration a number of factors including clinical signs and laboratory parameters. Another important issue to consider is the dog's stage of disease. In the face of acute CHF, the initial goal should be to titrate medication doses and to get the dog stabilized. In a dog with pulmonary edema or pleural effusion, the only diet change routinely advised during the initial period or even when first discharging the dog is to limit intake of very high sodium diets or high sodium treats. Once the dog is home and stabilized on medications, a gradual change to a new diet can be made - usually at the time of the first recheck 7-10 days after discharge. Forced dietary changes when the animal is sick or starting new medications may induce food aversions.

Failure to respond to pharmacologic and nutritional therapies can be the result of advanced or progressive disease, drug side effects, or incorrect diagnosis. Common pitfalls in the treatment of dogs with cardiac disease are shown in **Table 4**.

TABLE 4 - COMMON PITFALLS IN THE TREATMENT OF DOGS WITH CARDIAC DISEASE

Older small breed dogs with a cardiac murmur often have concurrent respiratory disease and it can be difficult to determine whether the clinical signs result from respiratory or cardiac disease Thoracic radiographs should always be obtained prior to initiation of diuretics and other cardiac medications.	**Large breed dogs with acquired cardiac disease often have either dilated cardiomyopathy or pericardial disease** Since both of these diseases can occur without significant abnormalities on cardiac auscultation, there may be a delay in accurate diagnosis unless one maintains a high degree of suspicion for these diseases.	**Failure to accept a new diet** Causes can include abrupt change, particularly if the diet is introduced at the same time that drug interventions are being introduced or adjusted.	**Anorexia** Both congestive heart failure and drug side effects can lead to anorexia. Failure to eat a cardiac diet is too often attributed to lack of palatability for the diet rather than consideration of the many other factors that might impact appetite.

4 - Pathophysiology and specific issues of nutritional management

In addition to medications, optimal treatment of dogs with cardiac disease also includes careful attention to the diet. Although sodium restriction is the nutritional modification most often thought of for dogs with cardiac disease (and sometimes is the only nutrient modification thought of), adjustment of a variety of nutrients may be beneficial for these animals. Research is now beginning to show that dietary factors may be able to modulate canine cardiac disease, either by slowing the progression, minimizing the number of medications required, improving quality of life, or in rare cases, actually curing the disease.

In the past, the goal of nutritional management for animals with cardiac disease was purely symptomatic. This was primarily due to the limited number of medications available for treatment, and in that situation, severe sodium restriction was beneficial for reducing fluid accumulation in animals with CHF. Now, with more effective medications available for use in dogs, severe sodium restriction is not critical in most dogs. The emphasis in the nutritional management of dogs with CHF is on providing the optimal number of calories for the individual patient, avoiding nutritional deficiencies and excesses, and gaining potential beneficial effects from pharmacologic doses of certain nutrients.

► Optimal weight maintenance

Both weight loss and obesity can be problems in animals with cardiac disease, and can adversely affect the dog's health.

> Cardiac cachexia

Dogs with CHF commonly demonstrate weight loss, termed cardiac cachexia **(Figure 2)**. This weight loss in animals with CHF is unlike that seen in a healthy dog that loses weight. In a healthy animal that is receiving insufficient calories to meet requirements (eg, a starving dog, a dog on a weight reduction diet), fat serves as the primary energy source and this helps to preserve lean body mass. In a dog with injury or illness, including CHF, amino acids from muscle are the primary source of energy, resulting in loss of lean body mass.

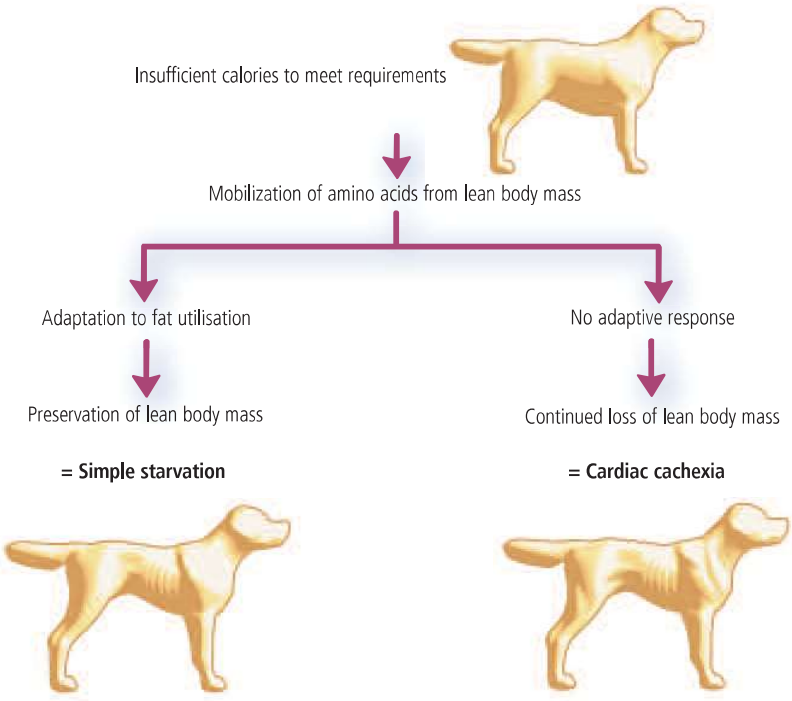
FIGURE 2 - CARDIAC CACHEXIA IN DOGS WITH CHF

a: Cardiac cachexia is often viewed as an end-stage situation like the dog shown here with severe dilated cardiomyopathy and congestive heart failure.

b: Cardiac cachexia is actually a process during which lean body mass is gradually lost. Cachexia can be very subtle initially and may be manifested only by mild muscle loss over the epaxial and gluteal muscles.

Therefore, a loss of lean body mass is the hallmark of cachexia. There is a spectrum of severity of cachexia and the term does not necessarily equate with an emaciated, end-stage patient **(Figures 3 & 4)**. In the early stages, it can be very subtle and may even occur in obese dogs (i.e. a dog may have excess fat stores but still lose lean body mass). Loss of lean body mass is usually first noted in the epaxial, gluteal, scapular, or temporal muscles. Cardiac cachexia typically does not occur until CHF has developed.

FIGURE 3 - EFFECTS OF STARVATION: DIFFERENCES BETWEEN A HEALTHY DOG AND A DOG WITH CARDIAC DISEASE



There is a dramatic difference between simple starvation, which occurs in a healthy animal and cachexia, the weight loss seen in animals with cardiac disease. A healthy animal will primarily lose fat tissue, whereas cachexia is distinguished by a loss of lean body mass.

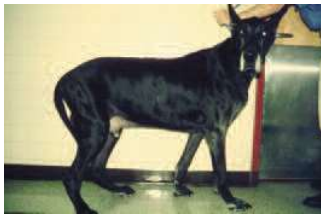
Cardiac cachexia can occur with any underlying cause of CHF (eg, DCM, CVD, congenital heart diseases) but most commonly occurs in dogs with DCM, particularly those with right-sided CHF. In one study of dogs with DCM, over 50% of patients had some degree of cachexia *(Freeman et al, 1998)*. Loss of lean body mass has deleterious effects on strength, immune function, and survival, so it is important to recognize cachexia at an early stage to explore opportunities to manage it effectively *(Freeman & Roubenoff, 1994)*.

The loss of lean body mass in cardiac cachexia is a multifactorial process caused by anorexia, increased energy requirements, and metabolic alterations *(Freeman & Roubenoff, 1994)*. The anorexia may be secondary to the fatigue or dyspnea or may be due to medication toxicity or feeding an unpalatable diet. Anorexia is present in 34-75% of dogs with cardiac disease *(Mallery et al, 1999; Freeman et al, 2003b)*. Although not yet measured in dogs with CHF, energy requirements up to 30% above normal have been documented in people with CHF *(Poehlman et al, 1994)*.

FIGURE 4 - DIFFERENT STAGES OF CACHEXIA

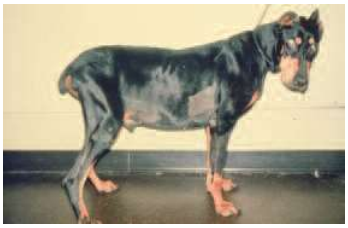
(a) Despite being trim, this dog has good muscle tone with no evidence of muscle wasting (Cachexia score = 0).

(b) Early, mild muscle wasting is present in this dog, especially in the hindquarters and lumbar region (Cachexia score = 1).



(c) Moderate muscle wasting, apparent in all muscle groups, is present. Note especially the atrophy of the temporal muscles and muscles over the shoulder (Cachexia score = 2).

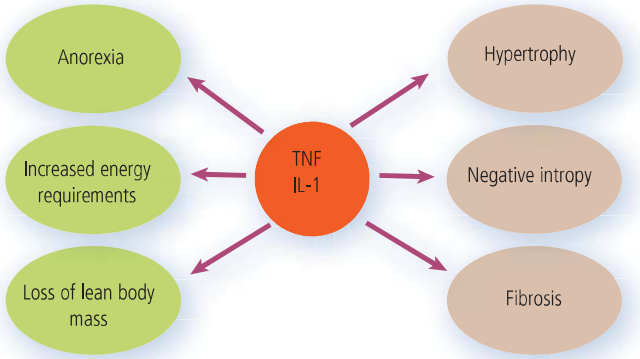
(d) Marked muscle wasting is present in this dog, as evidenced by the atrophy of all muscle groups (Cachexia score = 3).



(e) Severe muscle wasting can readily be seen in this dog (Cachexia score= 4).

While these factors play a role in the loss of lean body mass, a major factor in this syndrome is an increased production of inflammatory cytokines, such as tumor necrosis factor (TNF) and interleukin-1 (IL-1) *(Freeman et al, 1998; Meurs et al, 2002)*. These inflammatory cytokines are known to directly cause anorexia, to increase energy requirements, and to increase the catabolism of lean body mass. Of particular pertinence to cardiac disease, TNF and IL-1 also cause cardiac myocyte hypertrophy and fibrosis and have negative inotropic effects (Figure 5).

FIGURE 5 - CARDIOVASCULAR AND NUTRITIONAL EFFECTS OF THE INFLAMMATORY CYTOKINES, TUMOR NECROSIS FACTOR (TNF) AND INTERLEUKIN-1 (IL-1)

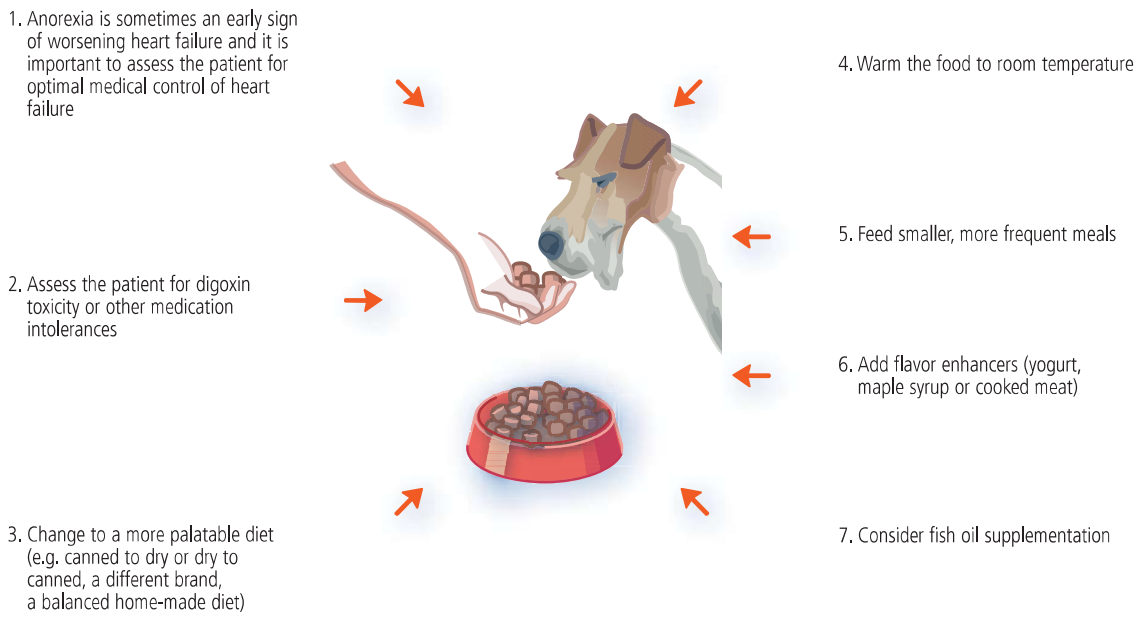


Nutritional management of dogs with cardiac cachexia consists primarily of providing adequate calories and protein and modulating cytokine production.

Anorexia can be detrimental to the dog with CHF in more than one way. Anorexia can be deleterious because it contributes to the syndrome of cardiac cachexia but, in addition, anorexia is one of the most common factors that contribute to a dog owner's decision of euthanasia. In one study of owners of dogs euthanized for CHF, anorexia was one of the most common contributing factors to the euthanasia decision *(Mallery et al, 1999)*. Anorexia is more common in dogs with CHF compared to asymptomatic dogs, and it also is more common in dogs with DCM compared to dogs with CVD *(Freeman et al, 2003b)*.

One of the most important issues for managing anorexia is to maintain optimal medical control of CHF. An early sign of worsening CHF is a reduction in food intake in a dog that has previously been eating well. Another possible cause of decreased appetite is the side effects of medications.

FIGURE 6 - KEYS TO NUTRITIONAL MANAGEMENT OF ANOREXIA IN PATIENTS WITH CARDIAC DISEASE



Digoxin toxicity or azotemia secondary to ACE inhibitors or overzealous diuretic use can both cause anorexia. Ensuring a diet that is palatable to the dog while maintaining other nutritional goals is key to minimizing the effects of cachexia in dogs with CHF. Tips that may assist in food intake include feeding small, more frequent meals or warming the food to body temperature (or for some dogs, feeding refrigerated food increases appetite). Gradual introduction of a more palatable diet may be beneficial for some dogs (e.g., switching from a dry food to a canned food, changing to a different brand, or having a veterinary nutritionist formulate a balanced homemade diet). It also may be useful to use flavor enhancers to increase food intake (e.g., yogurt, maple syrup, or honey) **(Figure 6)**.

Modulation of cytokine production can also be beneficial for managing cardiac cachexia. Although specific anti-TNF agents have not proven to be beneficial for people with CHF, dietary supplementation may be a safer method of reducing inflammatory cytokines. One method of decreasing the production and effects of cytokines is with n-3 polyunsaturated fatty acid supplementation (see discussion of n-3 fatty acids below). Supplementation of fish oil, which is high in n-3 fatty acids, can decrease cytokine production in dogs with CHF and improve cachexia *(Freeman et al, 1998)*. A reduction of IL-1 has been correlated with survival in dogs with CHF *(Freeman et al, 1998)*.

Optimal medical and nutritional therapy can help to reverse cachexia and improve nutritional status. Nutritional status is difficult to measure objectively in the ill patients but one parameter that can be evaluated is insulin-like growth factor-1 (IGF-1). In people and in dogs, IGF-1 concentrations have been used as an indicator of nutritional status *(Clark et al, 1996; Maxwell et al, 1998)*. Mean IGF-1 concentrations have been shown to be positively correlated with survival, suggesting that maintaining good nutritional status may be able to improve survival *(Freeman et al, 1998)*. In people with CHF, the presence of cachexia has proven to be a poor prognostic indicator *(Anker et al, 2003; Davos et al, 2003)*.

> Obesity

Although many dogs, particularly those with more advanced cardiac disease, have weight and muscle loss, some dogs with cardiac disease are overweight or obese **(Figure 7)**. Although cardiac implications of obesity have not been well-studied in dogs and coronary artery disease is not a major concern in dogs, obesity is thought to be deleterious in dogs with cardiac disease because of its documented adverse effects on cardiac output, pulmonary function, neurohumoral activation, blood pressure, and heart rate in people and in experimental animal models *(Alexander, 1986)*. In any obese dog, underlying endocrine diseases such as hypothyroidism and Cushing's disease should be ruled out, but most obese animals simply suffer from excess consumption of calories.

Figure 7 - A dog with chronic valvular disease complicated by severe obesity. *Obesity may exacerbate the disease. Owners of obese dogs with cardiac disease often report that, when the dog loses weight, it acts less dyspneic and more active.*

Weight reduction programs are a difficult and often frustrating endeavor. For information on obesity and weight reduction programs, **see Chapter 1**. However, one advantage when a dog has cardiac disease is that there is automatically an increased incentive for the owner to commit to a weight reduction plan. Although this may not ensure success, it aids in the first step of successful weight loss.

As with any weight reduction program, it is critical to perform a careful dietary history to determine and control all sources of caloric intake. This diet history is also beneficial in finding other food sources for the dog that may be contributing both calories and sodium. Typically, the pet food is only one source of calories for the pet and as many, or more, calories may be consumed from treats and table food. In one study of dogs with cardiac disease, calorie intake from treats and table food ranged from 0-100%, with a median calorie intake from treats of 19% *(Freeman et al, 2003b)*. Therefore, it is important to recommend specific treats that are reduced in both calories and sodium. Fresh non-starchy vegetables (or frozen/canned forms that are labeled as, "no salt added") are excellent low calorie treats for dogs that are obese and have cardiac disease.

If possible, an exercise program will help with the weight reduction program but, for dogs with CHF in which exercise restriction is recommended, this is not possible. For these dogs, the weight reduction program must rely on control of calorie intake.

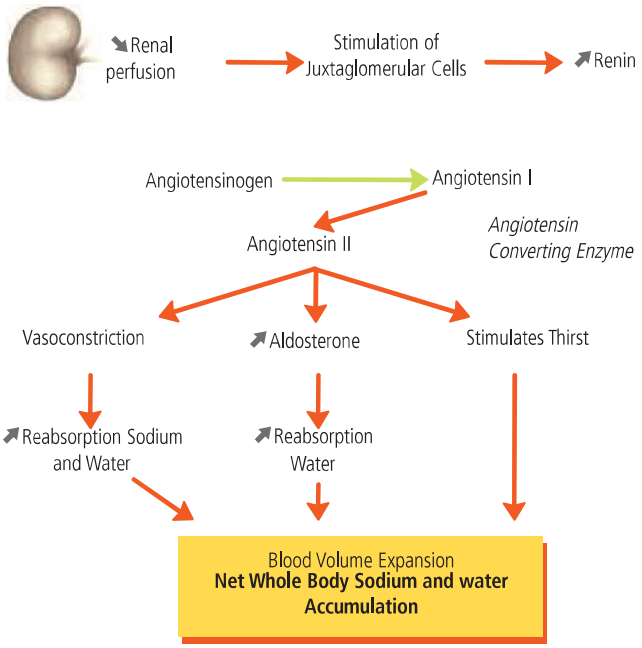
► Preventing nutrient excesses

Veterinarians have extrapolated from the human literature since the 1960's in applying nutritional recommendations to dogs with cardiac disease.

> Sodium and chloride

A prime example is sodium restriction. Healthy dogs can easily excrete excess dietary sodium in the urine but, even before clinical signs become apparent in dogs with cardiac disease, there is activation of the renin-angiotensin-aldosterone (RAA) system and abnormal excretion of sodium **(Figure 8)** *(Barger et al, 1955)*. Based on this pathophysiologic change, sodium restriction has been a mainstay of therapy for dogs with cardiac disease for nearly 50 years. However, very few studies have been conducted on dietary sodium in dogs with cardiac disease. Many questions remain on the specific intake of sodium recommended for dogs with different stages of disease, at what stage sodium restriction should be instituted, and if there are any detrimental effects of sodium restriction.

FIGURE 8 - PATHOGENESIS OF SODIUM RETENTION IN HEART DISEASE



• *Normal dogs*

Healthy dogs are relatively tolerant toward the sodium content of their diet.
An early study in 1964 showed no significant changes in extracellular water, sodium, or chloride in normal dogs fed a low sodium diet (*Pensinger, 1964*). This study also showed that healthy dogs were able to maintain sodium and potassium balance on both low and high sodium diets.

Two other studies found that normal dogs fed a low sodium diet had no changes in plasma sodium, chloride, or extracellular fluid volume compared to those fed a high sodium diet (*Hamlin et al, 1964; Morris et al, 1976*). In 1994, a study examined the effects of a low sodium diet and furosemide in healthy dogs with or without captopril (*Roudebush et al, 1994*). Although there were no within-group changes in electrolytes in this study, 3 of 6 dogs became hyperkalemic while receiving a low sodium diet plus furosemide and 2 of 6 became hyperkalemic while receiving a low sodium diet plus furosemide and captopril (*Roudebush et al, 1994*). The effects of the low sodium diet alone were not reported.

In normal dogs, low sodium diets caused an increase in plasma renin activity (PRA) and plasma aldosterone concentration compared to a high sodium diet, although plasma concentrations of ACE, atrial natriuretic peptide (ANP), arginine vasopressin (AVP), and endothelin-1 (ET-1) remained unchanged (*Pedersen et al, 1994a, Pedersen et al, 1994b*). Normal dogs receiving enalapril while eating a low-sodium diet, however, had an exaggerated increase in PRA and a larger decrease in ACE and ANP compared to a dogs eating a high sodium diet (*Koch et al, 1994*). These investigators also found an inverse correlation between PRA and sodium content of the diet (*Koch et al, 1994*).

• *Dogs with CHF*

Dogs with CHF respond differently to dietary sodium restriction. Sodium restriction is one method, along with the use of diuretics and venous vasodilators, to treat excessive increases in preload in patients with CHF. In the 1960's, when few medications were available for treating dogs with CHF, dietary sodium restriction was one of the few methods of reducing fluid accumulation. In this situation, severe sodium restriction clearly was beneficial in reducing signs of congestion.

In one study, dogs with CHF retained sodium on the high sodium diet but did not retain sodium on the low sodium diet (*Pensinger, 1964*). Untreated dogs with mild, asymptomatic mitral valve insufficiency had a larger increase in PRA and PAC and a lower ACE activity when changed from a high sodium diet to a low sodium diet (*Pedersen, 1996*). Sodium intake had no effect on endothelin-1, ANP, and AVP (*Pedersen, 1996*).

A randomized double-blind, placebo-controlled clinical trial of low sodium diets in dogs with CHF secondary to either CVD or DCM demonstrated no significant changes in neurohormones between a low sodium and moderate sodium diet (*Rush et al, 2000*). Serum sodium and chloride concentrations decreased significantly while dogs were eating the low sodium diet (*Rush et al, 2000*). Measures of cardiac size decreased significantly on the low sodium diet compared to the moderate sodium diet, especially in dogs with endocardiosis (*Rush et al, 2000*). The effects of a low sodium diet on survival were not tested.

The biggest gap in the issue of sodium restriction is for dogs with early cardiac disease [Stage I or II: **Table 5**] (International Small Animal Cardiac Health Council (*ISACHC), 2001*). Based on the pathogenesis of sodium retention, authors in the 1960's recommended institution of low-sodium diets for dogs when a heart murmur was first detected, even before clinical signs were present (*Morris, 1976*). Only recently have the benefits and potential problems been questioned. One of the earliest and major compensatory responses in cardiac disease is activation of the renin-angiotensin-aldosterone (RAA) system. Sodium restriction can further activate the RAA system (*Pedersen et al, 1994a-1994b; Koch et al, 1994*).

Table 5 - Dietary sodium recommendations for dogs based on stage of disease

International Small Animal Cardiac Health Council Classification*	Description	Dietary sodium recommendations
1 Asymptomatic Heart disease is detectable but patient is not overtly affected and does not demonstrate clinical signs of heart failure. Diagnostic findings could include a cardiac murmur, arrhythmia, or cardiac chamber enlargement that is detectable by radiography or echocardiography.	**1a** Signs of heart disease are present but no signs of compensation, such as volume or pressure overload or ventricular hypertrophy, are evident.	Severe sodium restriction is not required. Counsel the owner to avoid diets high in sodium (>100 mg/100 kcal) and to avoid treats and table foods that are high in sodium.
	1b Signs of heart disease are present in conjunction with radiographic or echocardiographic evidence of compensation, such as volume or pressure overload ventricular hypertrophy.	Sodium content of 50-80 mg/100 kcal in the main diet. Also counsel the owner to avoid treats and table foods that are high in sodium.
2 Mild to Moderate Heart Failure Clinical signs of heart failure are evident at rest or with mild exercise and adversely affect quality of life. Typical signs of heart failure include exercise intolerance, cough, tachypnea, mild respiratory distress (dyspnea), and mild to moderate ascites. Hypoperfusion at rest is generally not present.		Sodium content of 50-80 mg/100 kcal in the main diet. Greater sodium restriction (<50 mg/100 kcal) is recommended if large diuretic doses are necessary to control clinical signs. Limiting sodium intake from treats and table foods becomes more important. Counsel owner on appropriate methods for medication administration.
3 Advanced Heart Failure Clinical signs of advanced congestive heart failure are immediately obvious. These clinical signs include respiratory distress (dyspnea), marked ascites, profound exercise intolerance, or hypoperfusion at rest. In the most severe cases, the patient is moribund and suffers from cardiogenic shock. Death or severe debilitation is likely without therapy.	**3a** Home care is possible.	Sodium content <50 mg/100 kcal in the main diet. Limiting sodium intake from treats and table foods is very important. Counsel owner on appropriate methods for medication administration.
	3b Hospitalization is mandatory because cardiogenic shock, life-threatening pulmonary edema, refractory ascites, or a large pleural effusion is present.	Stabilization of acute CHF should be the goal. Diet changes should be avoided until the dog is home and stabilized on medications; a gradual change to a new diet can be instituted at that time.
	Note that these recommendations assume that the dog is not eating high sodium treats, table foods, or foods used for medication administration in addition to the main diet. If dogs are eating high sodium foods in addition to the main diet, the owner should be counselled regarding these foods or a diet lower in sodium should be selected. **From: International Small Animal Cardiac Health Council.*	

Thus, severe sodium restriction in dogs with early cardiac disease could theoretically be detrimental by early and excessive activation of the RAA system. Studies by Pensinger showed that dogs with cardiac disease but without CHF were able to maintain sodium and potassium balance on both low and high sodium diets, similar to normal dogs *(Pensinger, 1964)* but neurohormone changes were not measured. While any potential detrimental effects of early institution of severe dietary sodium restriction have not been shown, it is clear that all drug therapies shown to improve survival in CHF act by blunting neurohumoral activation. Therefore, severe sodium restriction (i.e., near the AAFCO minimum of 20 mg/100 kcal) is not currently recommended for dogs with ISACHC Stage 1 or 2 cardiac disease. Conversely, high dietary sodium intake in early disease is likely detrimental. **Table 5** summarizes the authors' current recommendations, based on available literature and clinical experience.

Most owners are unaware of the sodium content of pet foods and human foods and need very specific instructions regarding appropriate dog foods, acceptable low salt treats, and methods for administering medications **(Table 6)**. Owners also should be counselled on specific foods to avoid such as baby food, pickled foods, bread, pizza, condiments (e.g., ketchup, soy sauce), lunch meats and cold cuts (e.g., ham, corned beef, salami, sausages, bacon, hot dogs), most cheeses, processed foods (e.g., potato mixes, rice mixes, macaroni and cheese), canned vegetables (unless "no salt added"), and snack foods (e.g., potato chips, packaged popcorn, crackers).

Mildly reduced dietary sodium can be achieved with a therapeutic diet designed for animals with early cardiac disease or with certain diets designed for use in older dogs. If using a diet designed for senior dogs, be sure to look at the characteristics of the individual product. There is no legal definition for a senior diet so the levels of calories, protein, sodium, and other nutrients can vary dramatically between different companies' products. Diets designed for animals with renal disease are not recommended for most cardiac patients because of the protein restriction (unless severe renal dysfunction is present).

TABLE 6 - LOW SODIUM METHODS FOR ADMINISTERING MEDICATIONS

- Switch from pills to a compounded, flavored liquid medication. Be cautious in this approach because the pharmacokinetics of certain drugs may be altered when compounded
- Teach the owner to pill the animal without using foods. This may be done without any devices or by using devices designed for this purpose
- Use low sodium foods to insert the pills before administration
  - Fresh fruit (e.g., banana, orange, melon)
  - Low sodium canned pet food
  - Peanut butter (labeled as "no salt added")
  - Home-cooked meat (without salt) - not lunch meats

As CHF becomes more severe, more sodium restriction may allow lower dosages of diuretics to be used to control clinical signs. To achieve severe sodium restriction, it is usually necessary to feed a commercial therapeutic diet designed for cardiac patients. Typically, these diets are severely restricted in both sodium and chloride; levels of other nutrients vary with the individual product.

Dietary chloride levels are often ignored but research suggests that chloride may be important in the optimal management of CHF. Research in people has shown that sodium and chloride administration are necessary for the full expression of hypertension in people *(Boegehold & Kotchen, 1989)*. Chloride administration also appears to decrease plasma renin activity in salt depleted rats *(Kotchen et al, 1980; Muller, 1986)*.

The patient with heart failure has chronic activation of the RAA system, which could be significantly influenced by dietary chloride. In addition, furosemide is known to block chloride transport in the ascending loop of Henle, and hypochloremia (and hyponatremia) can develop in advanced CHF. Therefore, chloride is likely to play an important role in the CHF patient. Unfortunately, little is known about optimal dietary intake for CHF patients and additional research will be required to make specific recommendations.

> Potassium

In the past, when digoxin and diuretics were the mainstays of therapy for people and dogs with CHF, hypokalemic was a major consideration. Now, ACE inhibitor therapy has gained widespread

use in the management of dogs with CHF and this medication results in renal potassium sparing. Therefore, ACE inhibitors are known to cause increased serum potassium, with some animals developing hyperkalemia *(Roudebush et al, 1994; COVE Study Group, 1995; Rush et al, 1998)*. This can especially be a problem in animals eating commercial cardiac diets since some commercial cardiac diets contain increased potassium concentrations to counteract the theoretical loss due to diuretics.

In addition to the importance of the diets' compatibility with current ACE inhibitor use, other newer cardiac medications may also be used more commonly. Spironolactone, an aldosterone antagonist and a potassium-sparing diuretic is being used with greater frequency in veterinary patient after reports of improved survival in human CHF patients *(Pitt et al, 1999)*. This medication is even more likely than other diuretics to cause hyperkalemia. Finally, many people know about the association between diuretics and hypokalemia either from their own medical condition or that of a friend or relative, and some mistakenly give their dogs with CHF bananas or potassium supplements in an effort to prevent this problem. Routine monitoring of serum potassium is recommended for all patients with CHF, particularly those receiving an ACE inhibitor or spironolactone. If hyperkalemia is present, a diet with a lower potassium content should be selected.

► Preventing nutritional deficiencies versus nutritional pharmacology

Historically, a variety of nutritional deficiencies have been known to cause cardiac disease in various species. These include thiamine, magnesium, vitamin E, selenium, and taurine. Although nutritional deficiencies are generally uncommon (except in owners feeding unbalanced homemade diets), they may still play a role in some cardiac diseases of dogs. Nutritional deficiencies may also develop secondary to the disease or its treatment. There is also blurring of the lines between the benefits of correcting a nutritional deficiency (e.g. as in a cat with taurine deficiency-induced dilated cardiomyopathy) and the pharmacological effects of a nutrient (e.g. the positive inotropic effects of taurine). In addition, new information is coming out on species and even breed differences in nutrient requirements. Thus, there appears to be much more to providing optimal levels of nutrients than just preventing a deficiency.

> Protein and amino acids

- ***Protein***

In addition to sodium restriction, the dietary recommendations in the 1960's for dogs with CHF were to restrict protein intake to "reduce the metabolic load on congested, aging, and diseased kidneys and liver" *(Pensinger, 1964)*. Restricting protein can actually be detrimental in terms of lean body mass loss and malnutrition. Dogs with CHF should not be protein restricted, unless they have concurrent advanced renal disease. Some of the diets designed for dogs with cardiac disease are low in protein (3.6-4.2 gm/100 kcal). In addition, some veterinarians recommend protein-restricted renal diets for dogs with cardiac disease because these diets often (but not always) are also moderately sodium restricted.

Unless severe renal dysfunction is present (i.e., serum creatinine>3.0 mg/dL), high-quality protein should be fed to meet canine AAFCO minimums for adult maintenance requirements (5.1 gm/100 kcal; *Association of American Feed Control Officials (AAFCO), 2005*). In one study, daily protein intake of dogs with cardiac disease ranged from 2.3-18.8 g/100 kcal so some dogs with cardiac disease are clearly not eating sufficient dietary protein *(Freeman et al, 2003b)*.

Another misconception that impacts cardiac disease is the still widespread belief that dietary protein should be restricted in early renal disease **(see chapter 8)**. Although the majority of dogs treated with ACE inhibitors do not develop azotemia, some dogs receiving ACE inhibitors can develop azotemia *(COVE Study Group, 1995)*. Azotemia occurs more frequently when ACE inhibi-

tors are used in conjunction with diuretics although, in a small number of dogs, azotemia can develop from ACE inhibitors alone. When concurrent ACE inhibitor and diuretic use causes azotemia, reduction of the furosemide dose is indicated to reduce azotemia. A protein-restricted diet is not necessary in this situation unless medication changes do not correct the problem and the renal disease progresses.

- ***Taurine***

The association between taurine and feline DCM described in the late 1980's prompted investigators to examine the role of taurine in canine DCM *(Pion et al, 1987)*. Unlike cats, dogs are thought to be able to synthesize adequate amounts of taurine endogenously and taurine is not considered to be required in canine diets. Although initial studies showed that most dogs with DCM did not have low plasma taurine concentrations, certain breeds of dogs with DCM (eg, Cocker Spaniels and Golden Retrievers) did have low taurine concentrations *(Kramer et al, 1995)*. The association between dogs with DCM and low taurine concentrations has been best established in the American Cocker Spaniel *(Kramer et al, 1995; Kittleson et al, 1997)*.

In a study by Backus *et al*, 12 of 19 Newfoundlands tested had taurine concentrations consistent with taurine deficiency. However, none of these dogs had DCM *(Backus et al, 2003)*. Other commonly reported breeds of dogs with DCM and taurine deficiency include Golden Retriever, Labrador Retriever, Saint Bernard, English Setter *(Freeman et al, 2001; Fascetti et al, 2003)*.

When concurrent ACE inhibitor and diuretic use causes azotemia, reduction of the diuretic dose is indicated to reduce azotemia. A protein restricted diet is not necessary in this situation unless medication changes do not correct the problem and the renal disease progresses.

The first question about the relationship between canine DCM and taurine deficiency is whether DCM is caused by dietary deficiency.

In one retrospective study, 20 of 37 dogs with DCM tested for plasma and whole blood taurine concentrations were considered to be taurine-deficient **(***Freeman et al, 2001)*. There was no significant difference in mean dietary taurine content (based on manufacturers' information) between taurine deficient and non taurine deficient dogs, nor was there a correlation between dietary content and circulating taurine concentrations *(Freeman et al, 2001)*. Of the taurine deficient dogs, 7 were eating a lamb and rice based diet and seven were eating an increased fiber diet.

Twelve dogs with DCM and taurine deficiency were reported to be eating dry diets containing lamb meal, rice, or both as primary ingredients *(Fascetti et al, 2003)*.

In another study, 131 normal dogs were tested for plasma and whole blood taurine concentrations. In this study, dogs consuming diets containing rice bran or whole grain rice had lower taurine concentrations *(Delaney et al, 2003)*. Thus, it may be the rice bran component of diets that affects taurine concentrations although lamb meal also is known to have decreased amino acid digestibility *(Johnson et al, 1998)*.

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In a retrospective study, of the taurine deficient dogs, 7 were eating a lamb and rice based diet and 7 were eating an increased fiber diet.

Alternatively, dietary protein quality and quantity may also play a role in taurine deficiency. In one study, a group of Beagles fed a low taurine, very low protein diet for 48 months had a decrease in whole blood taurine concentrations and 1 of the 16 dogs developed DCM *(Sanderson, 2001)*.

Finally, some dog breeds may be predisposed to taurine deficiency when fed certain types of diets because of higher requirements or breed-specific metabolic abnormalities.

A second question that still remains is whether taurine supplementation reverses DCM in dogs with concurrent taurine deficiency.

In one small study, 11 Cocker Spaniels supplemented with taurine and carnitine showed improvement in clinical parameters and echocardiographic measurements *(Kittleson et al, 1997)*. Whether the response would be similar with taurine alone remains to be seen. In one small retrospec-

tive study that compared dogs with DCM that were taurine deficient and were treated with taurine (plus medical therapy) to dogs that were not taurine deficient, there was no difference in the number that were able to discontinue medications, in the furosemide dosage, in echocardiographic measurements, or survival *(Freeman et al, 2001)*. Another retrospective study of 12 dogs with DCM and taurine deficiency showed a within-group improvement in E-point to septal separation and fractional shortening after taurine supplementation but there was no comparison group *(Fascetti et al, 2003)*.

Minimum taurine requirements for dogs have not been established by AAFCO, but the minimum taurine requirement for adult cats is 25 mg/100 kcal for dry food and 50 mg/100 kcal for canned foods *(AAFCO, 2005)*. A diet with a taurine content of 50 mg/100 kcal would provide approximately 1000 mg/day of taurine to a 40 kg dog.

Response to therapy may be breed dependent. In a study of a litter of Portugese Water Dogs with DCM, taurine was below the reference range in eight of eight puppies tested, and DCM was diagnosed in eight of the nine puppies *(Alroy, 2000)*. Taurine supplementation was instituted in 6 of the puppies, which significantly increased plasma and whole blood taurine concentrations as well as cardiac function *(Alroy, 2000)*. In a study of Beagles fed a low taurine, very low protein diet for 48 months, the one dog that developed DCM had improvement in fractional shortening after three months of taurine supplementation *(Sanderson et al, 2001)*. Some of the potential benefits of taurine in dogs with DCM may be due to its positive inotropic effects or role in calcium regulation in the myocardium. Beneficial effects of taurine have been shown in animal models with experimentally-induced heart failure and in unblinded human clinical trials *(Elizarova et al, 1993, Azuma, 1994)*.


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In Cocker Spaniels with DCM, measuring plasma and whole blood taurine concentrations is recommended.

While it is unlikely that the breeds at high risk for DCM such as the Doberman Pinscher or the Boxer have taurine deficiency, certain breeds (eg, Cocker Spaniel, Newfoundlands, Golden Retrievers) and atypical breeds (eg, Scottish Terrier, Border Collie) may have concurrent taurine deficiency. Therefore, in these latter breeds, measuring plasma and whole blood taurine concentrations is recommended. In addition, taurine concentrations should be measured in dogs with DCM that are eating lamb meal and rice, very low protein, or increased fiber diets. Although the extent of the benefit of supplementation is not yet clear, taurine supplementation is recommended until plasma and whole blood taurine concentrations from the patient are available. Even in dogs with taurine deficiency that do respond to taurine supplementation, the response is generally not as dramatic as in taurine deficient cats with DCM. The optimal dose of taurine for correcting a deficiency has not been determined but the currently recommended dose is 500-1000 mg q 8-12 hours. Taurine can be provided as a supplement although certain diets may contain enough taurine to raise plasma taurine concentrations.

- ***Arginine***

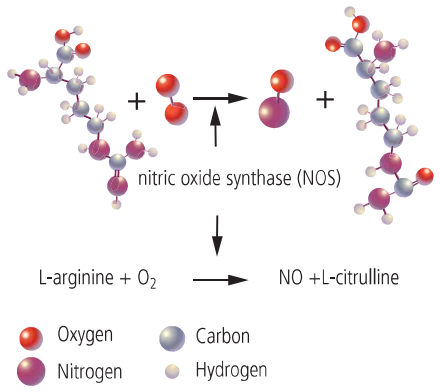
Nitric oxide is an endogenous vascular smooth muscle relaxant. It is synthesized from L-arginine and molecular oxygen **(Figure 9)**.

Circulating nitric oxide is elevated in people with CHF, regardless of the underlying cause and in two studies of dogs and cats with heart disease *(De Belder et al, 1993; Comini et al, 1999; De Laforcade et al, 2000; Freeman et al, 2003a)*. However, one study of dogs showed lower nitric oxide concentrations in dogs with untreated CVD *(Pedersen et al, 2003)*. High circulating nitric oxide levels may have an initial beneficial compensatory effect but can be detrimental when this response is prolonged. High levels of nitric oxide can have a negative inotropic effect and can decrease the responsiveness to beta-adrenergic stimulation *(Gulick et al, 1989; Yamamoto et al, 1997)*. There appear to be competing responses occurring in CHF. While iNOS is upregulated in patients with CHF producing high circulating levels of nitric oxide, eNOS is actually downregulated and reduces endothelium-dependent vasodilation *(Agnoletti et al, 1999, Katz et al, 2000)*.

The reduction in eNOS and resulting loss of normal vasodilation have adverse effects in the patient with CHF *(Feng et al, 1998)*. People with CHF have a reduction of peripheral blood flow both at rest and during exercise *(Maguire et al, 1998)*. This abnormality may contribute to exercise intolerance in these patients. Endothelial dysfunction has also been demonstrated in dogs with experimentally-induced CHF and is associated with decreased gene expression of eNOS *(Wang et al, 1997)*.

Based on the findings of endothelial dysfunction in patients with CHF, investigators have begun to study the effects of arginine supplementation in this group. In normal patients, L-arginine supplementation is unlikely to have an effect on nitric oxide production because L-arginine is found in concentrations much higher than the Km values for NOS *(Tsikas et al, 2000)*. But the situation in patients with CHF may be very different and, in fact, L-arginine supplementation has been shown to improve endothelial dysfunction *(Kubota et al a, 1997; Feng et al, 1999; Kanaya et al, 1999; Hambrecht et al, 2000)*. L-arginine supplementation has been tested in people with CHF in a number of studies *(Kubota et al, 1997; Kanaya et al, 1999; Banning & Prendergast, 1999; Bocchi et al, 2000; Hambrecht et al, 2000)*. These studies have shown increased circulating concentrations of nitric oxide but improved endothelium-dependent vasodilation and cardiac output. These studies also have shown reduced heart rate and systemic vascular resistance, with no negative effects on cardiac contractility or other echocardiographic variables *(Kubota et al, 1997; Hambrecht et al, 2000; Bocchi et al, 2000)*. Although one study of arginine supplementation found no effect on exercise tolerance, another study showed that L-arginine reduced dyspnea in response to increasing CO_2 production during exercise in people with severe chronic heart failure *(Kanaya et al, 1999; Banning & Prendergast, 1999)*. Thus, while much research is needed in this area, arginine supplementation may provide beneficial effects in patients with CHF.

FIGURE 9 - ORIGIN OF NITRIC OXIDE



The reaction is catalyzed by the enzyme, nitric oxide synthase (NOS). There are three forms of NOS:

- ***endothelial NOS (eNOS):*** *eNOS is required for maintenance of normal vascular tone and as a physiologic messenger*
- ***neuronal NOS (nNOS):*** *eNOS and nNOS are constitutive forms and are always produced in low levels*
- ***inducible NOS (iNOS):*** *iNOS is inducible by a variety of inflammatory mediators including the cytokines, tumor necrosis factor (TNF), and interleukin-1 (IL-1), and free radicals.*

> Fat

Fat is a source of calories and essential fatty acids and increases the palatability of the diet. However, depending upon the type of fat, it can have significant effects on immune function, the production of inflammatory mediators and even hemodynamics.

• *n-3 fatty acids*

Most human and canine diets contain primarily n-6 fatty acids. In n-6 fatty acids (eg linoleic acid, γ-linolenic acid, and arachidonic acid), the first double-bond is at the position of the 6th carbon from the methyl end. However, n-3 fatty acids [α-linolenic acid, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA)] have the first double-bond at the 3rd carbon from the methyl end. Although this seems like a minor change, it confers very different structure and characteristics to the fatty acid. Plasma membranes normally contain very low concentrations of n-3 fatty acids, but levels can be increased by a food or supplement enriched in n-3 fatty acids.

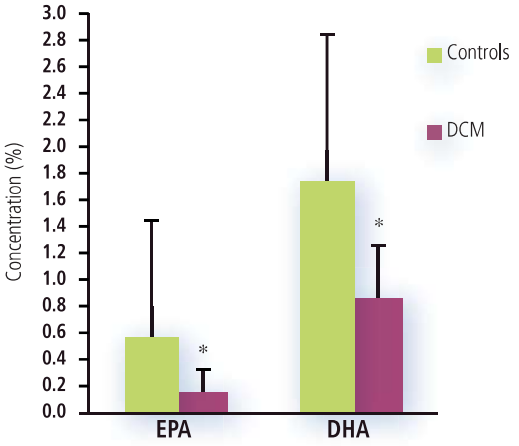
Dogs with heart failure have lower plasma concentrations of eicosapentaenoic acid (EPA; 20:5n-3) and docosahexaenoic acid (DHA; 22:6n-6), regardless of the underlying disease **(Figure 10)** *(Freeman et al, 1998; Rush et al, 2000)*. This alteration in plasma fatty acids has also been found in people with various diseases as well, suggesting that metabolic changes may occur in certain diseases that increase the use of n-3 fatty acids. Therefore, supplementation may improve an absolute or relative n-3 fatty acid "deficiency".

n-3 fatty acid supplementation also reduces the more inflammatory eicosanoids. n-3 fatty acids are known to reduce the production of the more inflammatory 2- and 4-series eicosanoids (eg, there is a shift from production of prostaglandin E2 to prostaglandin E3). In a study of dogs with DCM, dogs supplemented with fish oil had a greater reduction in prostaglandin E2 production compared to dogs receiving the placebo *(Freeman et al, 1998)*. This may have benefits in terms of reduced inflammation. n-3 fatty acids also are known to decrease the production of the inflammatory cytokines, TNF and IL-1, which are elevated in CHF *(Endres et al, 1989; Meydani et al, 1991; Freeman et al, 1998)*.

Fish oil supplementation reduced cachexia and, in some, but not all dogs with CHF-induced anorexia, improved food intake *(Freeman et al, 1998)*. Finally, n-3 fatty acids have been shown in a number of rodent, primate, and canine models to reduce arrhythmogenesis *(Charnock, 1994; Kang & Leaf, 1996; Billman et al, 1999)*. Many dogs with CVD and most dogs with DCM have arrhythmias. In some dogs with cardiac disease, sudden death due to arrhythmias is the first manifestation of the disease in otherwise asymptomatic dogs. Therefore, n-3 fatty acid supplementation may be beneficial even before CHF develops.

FIGURE 10 - PLASMA FATTY ACID CONCENTRATIONS IN DOGS WITH DILATED CARDIOMYOPATHY (DCM) AND HEART FAILURE (N=28) COMPARED TO HEALTHY CONTROL DOGS (N=5)

(From Freeman et al, 1998)



Dogs with DCM and heart failure had significantly lower plasma eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) concentrations compared to healthy control dogs.
**P<0.05.*
(mean +/- standard deviation)

• *n-3 fatty acid supplementation*

There is controversy as to whether dose of n-3 fatty acids or the ratio of n-6: n-3 fatty acids is more important for the beneficial effects of n-3 fatty acids. Some evidence points to the primary importance of the total n-3 dose but it may also be important to avoid a high n-6:n-3 ratio as well. Although an optimal dose has not been determined, the authors currently recommend a dosage of 40 mg/kg EPA and 25 mg/kg DHA for dogs with anorexia or cachexia. Unless the diet is one of a few specially designed therapeutic diets, supplementation will be necessary since other commercial diets will not achieve this n-3 fatty acid dose.

Although an optimal dose has not been determined, the authors currently recommend a dosage of 40 mg/kg EPA and 25 mg/kg DHA for dogs with anorexia or cachexia. Unless the diet is one of a few specially designed therapeutic diets, supplementation will be necessary since other commercial diets will not achieve this n-3 fatty acid dose.

The exact content of EPA and DHA in individual fish oil supplements varies widely. The most common formulation of fish oil, however, is one gram capsules that contain 180 mg EPA and 120 mg DHA. At this concentration, fish oil can be administered at a dose of 1 capsule per 10 pounds of body weight to achieve the authors' recommended EPA and DHA dose. Fish oil with higher concentrations of EPA and DHA can be obtained from medical supply catalogs and may be more feasible for large dogs.

Fish oil supplements should always contain vitamin E as an antioxidant, but other nutrients should not be included to avoid toxicities. Similarly, cod liver oil should not be used because of the possibility for vitamins A and D toxicity. Finally, although flax seed oil contains high levels of α-linolenic acid, this fatty acid must be converted to EPA and DHA for its beneficial effects. Species vary in the ability to make this conversion: dogs have the enzymes to convert it but with limited efficiency. **Therefore, flax seed oil is not recommended as an n-3 fatty acid supplement.**

> Minerals and vitamins

• *Potassium*

Potassium is an important electrolyte in cardiac patients for a number of reasons. Hypokalemia potentiates arrhythmias, causes muscle weakness, and predisposes patients to digitalis toxicity. In addition, Class I antiarrhythmic drugs, such as procainamide and quinidine, are relatively ineffective in the face of hypokalemia. Hypokalemia was considered to be a common problem in the past when diuretics were the mainstays of therapy. Many of the medications used in dogs with CHF can predispose a patient to hypokalemia, including loop diuretics (eg, furosemide) and thiazide diuretics (eg, hydrochlorothiazide). However, with the increased use of ACE inhibitors, hypokalemia is no longer very common in dogs with CHF.

In addition to medication effects, inadequate dietary intake could predispose a dog to hypokalemia. In one study, 49% of dogs with cardiac disease ate less potassium than the AAFCO minimum value (170 mg/100 kcal). Intakes ranged from 37-443 mg/100 kcal *(Freeman et al, 2003b)*. This suggests that, based on dietary intake alone, some dogs may be predisposed to hypokalemia (in addition to the risk for hyperkalemia previously discussed) and underscores the importance of monitoring serum potassium in dogs with CHF.

• *Magnesium*

Magnesium is an essential prosthetic group in hundreds of enzymatic reactions involving carbohydrate and fatty acid metabolism, protein and nucleic acid synthesis, the adenylate cyclase system, and cardiac and smooth muscle contractility. Thus, magnesium plays an important role in normal cardiovascular function. It is also clear that alterations in magnesium homeostasis in people and dogs are common, and can have deleterious effects in a variety of cardiovascular conditions including hypertension, coronary artery disease, congestive heart failure, and cardiac arrhythmias *(Resnick, 1984; Rayssiguer, 1984; Gottleib et al, 1990; Iseri, 1986; Cobb & Michell, 1992)*. In addition, numerous drugs used to treat cardiac conditions, including digoxin and loop diuretics are associated with magnesium depletion *(Quamme & Dirks, 1994)*. Therefore, dogs with heart failure receiving these medications have the potential to develop hypomagnesemia. Hypomagnesemia can increase the risk of arrhythmias, decrease cardiac contractility, and can potentiate the adverse effects of cardiac medications.

There have been conflicting reports on the prevalence of hypomagnesemia in dogs with cardiac disease. Reports range from "uncommon" *(O'Keefe et al, 1993)* to 2/84 *(Edwards et al, 1991)*; fifty percent *(Rush, 2000)* to two-thirds of Lasix-treated dogs *(Cobb & Michell, 1992)*.

Hypokalemia was considered to be a common problem in the past when diuretics were the mainstays of therapy. Many of the medications used in dogs with CHF can predispose a patient to hypokalemia, including loop diuretics (eg, furosemide) and thiazide diuretics (eg, hydrochlorothiazide). However, with the increased use of ACE inhibitors, hypokalemia is no longer very common in dogs with CHF.

One of the difficulties in diagnosing magnesium deficiency is that only one percent of the total body magnesium is in the extracellular space. Therefore, normal serum magnesium does not necessarily mean there are adequate total body stores. Serial measurements of serum magnesium are currently recommended, especially in dogs with arrhythmias or those receiving large doses of diuretics. If low serum magnesium concentrations do arise and the dog is eating a diet that is low in magnesium, a diet higher in magnesium may be beneficial. Magnesium concentrations vary widely in commercial pet foods. Commercial reduced sodium diets for dogs can contain between 9-40 mg magnesium/100 kcal (compared to an AAFCO minimum of 10 mg/100 kcal). If the dog remains hypomagnesemic, oral magnesium supplementation will be required (e.g. magnesium oxide).

• *B vitamins*

(Table 7)

Little research has been conducted on the prevalence of B vitamin deficiencies in dogs with cardiac disease. However, there have long been concerns over the risk of B vitamin deficiencies in CHF due to anorexia and urinary loss of water soluble vitamins secondary to diuretic use. This

may be less of a problem now that there are more effective medications for treatment of CHF but even in one study from 1991, 91% of people with CHF had low thiamine concentrations *(Seligmann et al, 1991)*. In this study, patients were being treated with furosemide, ACE inhibitors, nitrates, and digoxin (where appropriate).

Low doses of furosemide were shown to cause increased urinary loss of thiamine in healthy people and in rats *(Rieck et al, 1999; Lubetsky et al, 1999)*. Although B vitamin status has not been reported for dogs with CHF, they may have higher dietary B vitamin requirements. Most commercial cardiac diets contain increased levels of water soluble vitamins to offset urinary losses so supplementation usually is not required.

> Other nutrients

• *Antioxidants*

Much attention has been given to antioxidants for their potential role in the prevention and treatment of human cardiac diseases. Reactive oxygen species are a by-product of oxygen metabolism for which the body normally compensates through the production of endogenous antioxidants. An imbalance between oxidant production and antioxidant protection (eg, oxidative stress), however, could increase the risk for cardiac disease **(Figure 11)**. Antioxidants are produced endogenously but also can be supplied exogenously. The major antioxidants include enzymatic antioxidants (e.g., superoxide dismutase, catalase, glutathione peroxidase) and oxidant quenchers (e.g., vitamin C, vitamin E, glutathione, and β-carotene).

Oxidative stress has been implicated in the development of a number of cardiac diseases. Increased oxidative stress has been demonstrated in people with CHF *(Belch et al, 1991; Keith et al, 1998)*. In dogs with heart failure, regardless of the underlying cause, there are increased levels of biomarkers of oxidative stress and a reduction in certain antioxidants, particularly vitamin E *(Freeman et al, 1999; Freeman et al, 2005)*. These alterations suggest an imbalance between oxidant stress and antioxidant protection in dogs with CHF.

Additional research is required to evaluate the effect, but antioxidant supplementation may hold promise in the future for the therapy of animals with cardiac disease.

TABLE 7 - VITAMINS OF GROUP B

Name	Abbreviations
Thiamin	B1
Riboflavin	B2
Pantothenic acid	*(B5*)*
Pyridoxine	B6
Biotin	*(B8*)*
Folic acid	*(B9*)*
Cobalamin	B12
Niacin	PP
Choline	

* *also called*

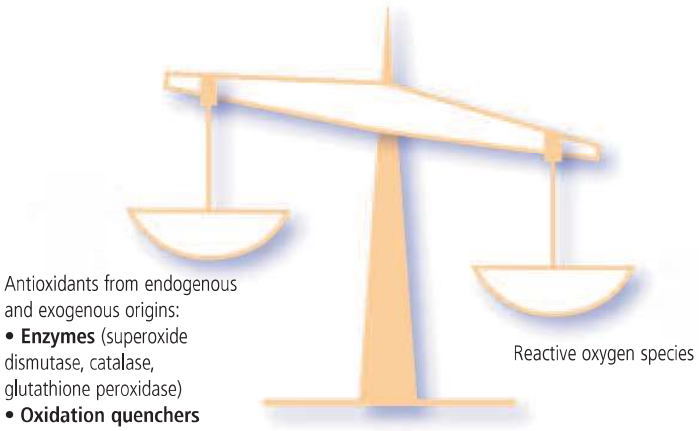
• *L-Carnitine*

L-Carnitine is a quaternary amine **(Figure 12)** whose major role is in long-chain fatty acid metabolism and energy production. Carnitine deficiency syndromes in people have been associated with primary myocardial disease and, based on this and its high concentrations in cardiac muscle, its role in canine DCM also has been of interest.

L-carnitine deficiency was reported in a family of Boxers in 1991 *(Keene et al, 1991)*. Since that time, L-carnitine supplementation has been used in some dogs with DCM but no blinded prospective studies have been done so a causative role has not been established. In human DCM patients, most studies of L-carnitine have not been well-controlled. However, one randomized, double-blind, placebo-controlled study showed improved three-year survival in human DCM patients receiving 2 gm/day L-carnitine *(Rizos, 2000)*.

One of the difficult aspects of studying L-carnitine in DCM is that one must measure myocardial concentrations since plasma concentrations are often normal even in the face of myocardial deficiency. Therefore, the advancement of knowledge of the role of this nutrient in DCM has been slow. It is not yet clear whether the carnitine deficiency seen in some dogs with DCM is the cause of the disease or merely secondary to the development of CHF. One study of dogs with heart failure induced by rapid pacing showed that myocardial concentrations decreased in normal dogs after the onset of CHF *(Pierpont et al, 1993)*. However, even if L-carnitine deficiency is not the inciting cause of DCM, supplementation may still provide benefits by improving myocardial energy production.

FIGURE 11 - ORIGIN OF OXIDATIVE STRESS



Oxidative stress comes from the imbalance between the production of free radicals and antioxidant defenses.

L-carnitine supplementation has few side effects but it is expensive and this may be a significant deterrent for some owners. The authors offer the option of L-carnitine supplementation to owners of dogs with DCM, especially Boxers and Cocker spaniels, but do not consider it essential. The minimum or optimal dose of L-carnitine necessary to replete a dog with low myocardial carnitine concentrations is not known, but the currently recommended dose is 50-100 mg/kg PO q 8 hours.

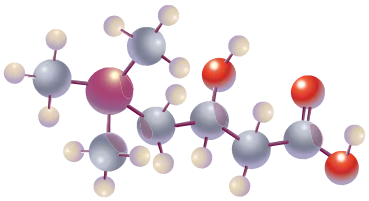
• *Coenzyme Q10*

Coenzyme Q10 is a cofactor required for energy production and has antioxidant properties. There are a number of mechanisms by which coenzyme Q10 might play a role in cardiac disease. Some investigators have proposed coenzyme Q10 deficiency as a possible cause for DCM but this has not been proven. Even in dogs with experimentally-induced CHF, serum coenzyme Q10 levels were not reduced *(Harker-Murray et al, 2000)*.

The minimum or optimal dose of L-carnitine necessary to replete a dog with low myocardial carnitine concentrations is not known, but the currently recommended dose is 50-100 mg/kg PO q 8 hours.

The most enthusiasm for coenzyme Q10 has been as a dietary supplement in the treatment of people or dogs with DCM. Coenzyme Q10 supplementation has anecdotally been reported to be beneficial but most of the human studies of coenzyme Q10 supplementation have not been well-controlled and results are conflicting. However, some encouraging results have been found *(Langsjoen et al, 1994; Sacher et al, 1997; Munkholm et al, 1999)*. In one study of dogs with experimentally-induced CHF, coenzyme Q10 supplementation increased serum, but not myocardial, concentrations *(Harker-Murray et al, 2000)*. The bioavailability of coenzyme Q10 varies in different tissues and also depends upon the degree of tissue deficiency in that tissue.

FIGURE 12 - CARNITINE MOLECULE



Discovered in 1905, L-carnitine is synthetized in dogs from lysine and methionine, if vitamin C and pyridoxine (vit B6) are present. It is a quaternary amine that acts as a water soluble vitamin. Carnitine can be synthetized in D or L forms, but L-carnitine is the only one of relevance for dogs with cardiac disease.

The current recommended dose in canine patients is 30 mg PO BID, although up to 90 mg PO BID has been recommended for large dogs. The purported benefits of supplementation include correction of a deficiency, improved myocardial metabolic efficiency, and increased antioxidant protection. Controlled prospective studies will be necessary to accurately judge the efficacy of this supplement.

5 - General issues in feeding dogs with cardiac disease

Dietary modification in dogs needs to be individualized - not all dogs with cardiac disease will need the same dietary formulation. Patients with cardiac disease vary in terms of their clinical signs, laboratory parameters, and food preferences and these should all affect diet selection. For example, more severe sodium restriction would be required for a dog with DCM and CHF than for a dog with asymptomatic DCM. Dogs with cardiac cachexia require a calorically-dense diet while an overweight dog should be fed a calorically-restricted diet. Dogs with cardiac disease may be hyper-, hypo-, or normokalemic and this will influence the choice of diet.

Concurrent diseases also influence diet choice and, in one study, concurrent diseases were present in 61% of dogs with cardiac disease (*Freeman et al, 2003b*). For example, a dog with CVD and colitis would need a diet that is sodium restricted but also one that has nutritional modifications to help manage the colitis (eg, reduced fat, increased fiber).

Based on these patient parameters, a diet or diets can be selected for the individual patient. There currently are a number of commercial veterinary diets available that are specifically designed for animals with cardiac disease. Specific characteristics of these foods vary, but they are moderately to severely sodium restricted and generally contain increased levels of B vitamins. Some cardiac diets also may include increased levels of taurine, carnitine, antioxidants, or n-3 fatty acids. In some cases, a "cardiac" diet may not be needed as some over-the-counter diets may have the properties desired for an individual dog. The authors also recommend offering more than one diet that would be appropriate for a dog so that the owner can see which is most palatable to the pet. Having a number of dietary choices is particularly beneficial for more severely affected CHF patients, in which a cyclical or selective loss of appetite is common.

In addition to the dog food(s) selected, one must also give the owner careful instructions on treats and table food. In some cases, dogs may be eating an ideal dog food but are getting large amounts of sodium from treats. In one study, over 90% of dogs with cardiac disease received treats and these dogs were receiving up to 100% of their sodium (median, 25%) from treats (*Freeman et al, 2003b*).

Therefore, in addition to finding a diet that has the desired nutritional properties and palatability, it also is important to devise an overall dietary plan that meets the owner's expectations. This includes devising a satisfactory method for administering medications. Most people administering medications to their dogs use foods as a way to administer the medication *(Freeman et al, 2003b)*. Discussing appropriate options for an owner to use for this purpose is necessary, as the foods most commonly used by owners are very high in sodium (eg, cheese, lunch meats, etc). Including all forms of dietary intake in the overall diet plan is important to achieve success with nutritional modification.

In many cases, the desired nutrient modifications can be achieved through diet alone. However, supplementation of certain nutrients may be desirable if they are either not in a particular diet or not at high enough levels to achieve the desired effect. One issue with the administration of dietary supplements is that they should not take the place of standard cardiac medications (eg, ACE inhibitors, diuretics). Dogs with severe CHF may be receiving 10-20 pills per day and it may be difficult for the owner to give supplements on top of this without discontinuing one or more of the cardiac medications. It is important to ask each owner about any dietary supplements being used as this is often not information that is volunteered (ie, dietary supplements are often not considered medications or diet). This will help to determine if any harmful supplements are being given and if the supplements are being given at an appropriate dose. In situations in which pill administration is becoming overwhelming for an owner, the veterinarian can assist the owner in determining which dietary supplements have the least potential benefits and can be discontinued.

There currently are a number of commercial veterinary diets available that are specifically designed for animals with cardiac disease. Specific characteristics of these foods vary, but they are moderately to severely sodium restricted and generally contain increased levels of B vitamins. Some cardiac diets also may include increased levels of taurine, carnitine, antioxidants, or n-3 fatty acids.

Finally, owners should be aware that dietary supplements are not regulated in the same way as drugs. They do not require proof of safety, efficacy, or quality control before they can be sold. Therefore, careful selection of type, dose, and brand is important to avoid toxicities or complete lack of efficacy.

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EXAMPLES OF HOME-PREPARED THE TREATMENT OF

Example 1

COMPOSITION
(1000 g diet)

Pork, shoulder with skin ..... 525 g
Rice, cooked ..... 435 g
Wheat bran ..... 30 g
Rapeseed oil ..... 10 g

Add a low-sodium mineral and vitamin supplement.

ANALYSIS		
The diet prepared in this way contains 30% dry matter and 70% water		
	% dry matter	g/1000 kcal
Protein	31	59
Fat	28	55
Available carbohydrate	34	66
Fiber	4	9

INDICATIVE RATIONING			
Energy value (metabolizable energy) 1810 kcal/1000 g diet prepared (5990 kcal/1000 g DM)			
Dog's weight (kg)*	Daily amount (g)**	Dog's weight (kg)*	Daily amount (g)**
2	120	45	1250
4	200	50	1350
6	280	55	1450
10	400	60	1550
15	550	65	1640
20	680	70	1740
25	800	75	1830
30	920	80	1920
35	1030	85	2010
40	1140	90	2100

Key Points

- **Energy concentration** to combat cardiac cachexia
- **Moderated sodium content** to facilitate the work of the heart

** The diet is offered in accordance with the dog's healthy weight. For obesity, the diet must be prescribed in accordance with the ideal weight and not the real weight of the dog.*
*** Dividing the diet into two meals is recommended to promote proper digestion.*

DIETS ADAPTED TO CARDIAC COMPLAINTS

Example 2

COMPOSITION
(1000 g diet)

Tuna ..... 500 g
Rice, cooked ..... 450 g
Wheat bran ..... 25 g
Rapeseed oil ..... 25 g

Add a low-sodium mineral and vitamin supplement.

INDICATIVE RATIONING			
Energy value (metabolizable energy) 1935 kcal/1000 g diet prepared (5180 kcal/1000 g DM)			
Dog's weight (kg)*	Daily amount (g)**	Dog's weight (kg)*	Daily amount (g)**
2	110	45	1170
4	190	50	1260
6	260	55	1360
10	380	60	1450
15	510	65	1540
20	640	70	1630
25	750	75	1710
30	860	80	1800
35	970	85	1880
40	1070	90	1960

ANALYSIS		
The diet prepared in this way contains 37% dry matter and 63% water		
	% dry matter	g/1000 kcal
Protein	33	63
Fat	28	54
Available carbohydrate	33	64
Fiber	4	7

Contra-indications

Gestation
Lactation
Growth
State of sodium depletion

Examples of home-made diets are proposed by Pr Patrick Nguyen
(Nutrition and Endocrinology Unit; Biology and Pathology Department, National veterinary School of Nantes)

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The majority of cardiac dogs suffer from systolic failure due either to acquired chronic valvular disease (endocardiosis) or dilated cardiomyopathy (DCM). The former disease very often affects small-breed dogs. DCM is most common in large-breed dogs.

Key Points
to remember:

The role of nutrition in cardiac disease

• One of the main goals of dietetic strategy is to achieve **optimal body weight** whatever the initial situation: obesity (especially in case of a subclinical disease) or cachexia in some severe cardiac diseases. Anorexia is a common phenomenon in cardiac patients that needs to be given due consideration: it is one of the main reasons for the request to euthanize patients with severe cardiac disease. It may be directly linked to respiratory problems, to fatigue accompanying heart failure, to nausea induced by medication or to poor palatability of certain cardiac diets, containing low sodium and protein content.

Selecting a **palatable food**, giving frequent small meals and encouraging the dog to eat are all measures that should not be neglected in therapeutic management.

• Cardiac dogs often suffer from a **deficiency of EPA-DHA**, long-chain n-3 fatty acids. A food with a higher EPA-DHA content facilitates the treatment of cardiac cachexia.

• **Severe sodium restriction has been inappropriately recommended for far too long.** Its application is unwarranted in the initial stages of heart failure, as it risks hastening the progression of the cardiac disease by activating the renin-angiotensin system, especially when angiotensin converting enzyme (ACE) inhibitors are simultaneously prescribed.

A moderate restriction of sodium content (< 80-100 mg/100 kcal) is sufficient for stages I and II of heart failure. Only severe heart failure justifies restricting sodium content to 50 mg/100 kcal.

• **A cardiac dog must receive a normal intake of high quality proteins to combat cardiac cachexia.** Limiting the protein intake is not indicated, except for concomitant hepatic encephalopathy or kidney disease that demands such a restriction. Taurine supplementation is recommended as this sulfated amino acid has positive properties that can prove effective in the prevention and treatment of dilated cardiomyopathy.

• **Arginine is a precursor of nitric oxide** (NO), which has been identified as a relaxation factor for the smooth muscle of blood vessels. Supplementary arginine intake will indirectly help combat hypertension.

• **L-carnitine is concentrated in the striated muscles and the heart** where it plays a key role in providing energy to the cells. L-carnitine deficiency has been suggested in connection with dilated cardiomyopathy. Clinical improvements have been reported after the administration of a supplement, although several months of treatment are necessary to achieve changes that can be detectable by echocardiography.

• Free radicals, which are responsible for oxidation of membranous phospholipids, aggravate cardiac lesions. Oxidative stress is a causal factor of dilated cardiomyopathy. The **daily administration of antioxidants in the food** is one of the main ways of combating the progression of heart failure.

Focus on:

THE IMPORTANCE OF TAURINE INTAKE TO ENCOURAGE OPTIMAL CARDIAC CONTRACTILITY

Taurine accounts for at least 40% of the pool of free amino acids in the heart. This amino acid is normally synthesized in the dog from methionine and cystine. The taurine concentration can be limited in certain conditions such as when the animal receives a food with reduced protein content or when taurine synthesis is insufficient, as is the case in some breeds and some lines. The synthesis of taurine appears to be much less efficient in large-breed dogs (> 35 kg) compared to Beagles *(Ko et al, 2005)*.

A simple blood sample will help determine whether the dog has taurine deficiency. Taurine analysis should be performed on whole blood as taurine is stored predominantly in blood cells. The plasma taurine concentration does not properly reflect the muscular and cardiac storage of taurine.

Taurine is essential to the contractility of the heart muscle.

1. It has a positive or negative inotropic effect depending on whether calcium is abundant or not in the cells; taurine protects the myocytes against the effects of excess calcium *(Satoh & Sperelakis, 1998)*.

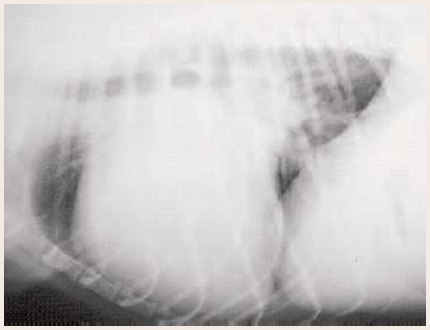
2. It has an antiarrhythmic role *(Satoh & Sperelakis, 1998)*.

3. It helps preserve the integrity of cardiac muscle cells: in vitro taurine prevents myocyte hypertrophy induced by angiotensin II *(Takahahsi et al, 1998)*.

It has long been known that taurine deficiency can provoke degeneration of the retina and slow down growth. Only recently has DCM in dogs been associated with extremely low plasma taurine levels.

The correlation has especially been shown in Newfoundland dogs in the United Kingdom *(Dukes-McEwan et al, 2001)*. Positive responses to taurine supplementation have been noted in Boxers suffering from DCM. It is therefore advisable to provide sufficient quantities of taurine in the food to prevent any risk of deficiency.

LATERAL THORACIC RADIOGRAPH OF A LARGE-BREED DOG WITH DILATED CARDIOMYOPATHY



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Generalized cardiomegaly during cardiomyopathy with clinical signs.

Heart

References

Dukes-McEwan J, Biourge V, Ridyard A et al. - Dilated cardiomyopathy in Newfoundland dogs: association with low whole blood taurine level. Proceedings of the British Small Animal Veterinary Association Congress. J Small Anim Pract 2001: 500.

Ko K, Backus RC, Berg JR et al. - In vivo taurine biosynthesis is greater in small dogs than large dogs. Waltham International Nutritional Sciences Symposium, Sept 15, 2005; Washington DC, USA.

Satoh H, Sperelakis N - Review of some actions of taurine on ion channels of cardiac muscle cells and others. Gen Pharmacol 1998; 30(4): 451-63.

Takahahsi K, Azuma M, Baba A et al. - Taurine improves angiotensin II-induced hypertrophy of cultured neonatal rat heart cells. Adv Exp Med Biol 1998; 442: 129-135.

Summary of select publications...

There is a hypothesis associating dilated cardiomyopathy (DCM) in dogs, especially large breeds, with taurine deficiency. This study was designed to evaluate the taurine status of a group of Newfoundland dogs in the United Kingdom. One hundred and four Newfoundlands underwent clinical and echocardiography examinations. The evaluation of taurine status was based on total blood analysis (nmol/mL). In addition, a detailed dietary history was obtained for each dog. The echocardiography examinations permited the classification of dogs as normal, dogs with dilated cardiomyopathy, dogs with a reduction in shortening fraction or dogs presenting with dilatation of the left ventricle.

A low taurine concentration is considered less than 200 nmol/mL, and a very low taurine level is less than 130 nmol/mL.

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	Combination of echocardiographic results and total blood taurine concentrations (average nmol/mL ± standard deviation)		
	Total blood taurine concentration		
	Average	< 200 nmol/mL	<130 nmol/mL
Normal dogs (n=49)	247±73	7	3
Dog with a reduction in the shortening fraction (n=39)	215±67	14	4
Dogs with DCM (n=11)	184±62	3	4
Dogs with dilatation of the left ventricle (n=5)	187±116	3	1

The taurine concentrations are significantly lower in dogs with DCM compared with normal dogs (ANOVA p=0.02)

Reference

Biourge V, Dukes-McEwan J, Desprez G et al.-Association between low whole blood taurine and Dilated CardioMyopathy (DCM) In Newfoundland dogs. ESVCN 2001, abstract.

A low taurine concentration has been shown in a significant number of Newfoundland dogs. In this study population, the taurine values tended to be lower than in dogs with dilated cardiomyopathy (DCM). The purpose of this study was to test the impact of taurine or methionine supplementation in correcting taurine deficiency.

Forty-eight dogs with a blood taurine value less than 200 nmol/mL were identified. Echocardiography examination enabled the establishment of three categories of dogs: normal, echocardiography anomalies without clinical signs (e.g. reduced contractility or dilatation of the left ventricle) and dogs with clinical DCM.

The dogs with clinical DCM received 1000 mg of taurine by mouth twice a day. The remaining dogs were matched by age and sex and then received 250 mg of taurine or 750 mg of methionine per os twice a day. Four dogs were fed with a specific food for very-large dogs.

The blood and urine taurine concentration, as well as the urine creatinine concentration were measured after three and six months of supplementation and compared with the initial values.

The blood taurine concentration increased in all the dogs. It rose from 144±8 nmol/mL at the start of the study to 324±14 nmol/mL after three months of supplementation and 275±10 nmol/mL after six months of supplementation. No differences could be distinguished with respect to the type or dose of supplementation.

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The urine taurine/creatinine ratio was minimal at the start of the study, increasing significantly with supplementation of methionine or taurine, more makedly with the highest taurine concentration.

These results suggest that 250 mg of taurine or 750 mg of methionine per os twice a day, and a diet providing 1000 mg of taurine/kg normalizes the taurine concentration in taurine deficient Newfoundland dogs. For the dogs in this study, a low taurine status cannot be explained by greater taurine losses or an inability to utilize methionine as a taurine precursor.

Reference

Willitz R, Desprez G, Duke-McEwans J et al. - Six months taurine or methionine supplementation in 53 Newfoundland Dogs suffering from low whole blood taurine. ESCVN 2002, abstract.