Nutrient Deficiencies in an Eight Month Old Dog on a Homemade Diet

Case Summary:

This report summarizes the nutritional management of an eight month old, Saint Bernard dog fed an unbalanced homemade diet, which did not meet the growth nutrient requirements. This dog exhibited hypocalcemic tetany and mandibular osteopenia. The patient was transitioned to a balanced diet that repleted specific nutrients and met growth recommendations, while avoiding over-consumption of key nutrients associated with developmental orthopedic disease in large-breed puppies.

** This case report was originally submitted by an ACVN candidate but has been edited and reformatted to meet the Instructions for the Writing and Evaluation of ACVN Case Reports. The example case reports are intended to serve as an illustration of the report instructions, format and a clinical presentation that had been found acceptable in the past. Editorial liberties were taken to complete the information essential to the report. Example reports should not be taken as an ACVN's endorsement of any specific nutritional approach or rationale.*

An eight month old male Saint Bernard was referred to a teaching hospital for bilateral shoulder osteochondritis dissecans (OCD) after a 2-month history of bilateral forelimb lameness. The owner had acquired the dog from a distant breeder at 11 wks (weeks) of age at which time the dog was having small bowel diarrhea while eating the breeder recommended chicken-based adult dry Diet A[a] at '3/4 cup' (75 g) q8 hr (hour). After 7 days of diarrhea, the owner changed the diet to a homemade mixture of boiled 90-93% lean hamburger and white rice feeding an unmeasured amount q8hr. The diarrhea resolved within 3 days, and the homemade diet was continued for the next 5 months at increasing amounts as the dog grew. The owner supplemented the mixture, made in weekly batches, with a canine dietary supplement[b] and single item foods in hopes of making the homemade diet (Diet B) nutritionally complete (Table #1). The dog received vaccinations and deworming through a local general practitioner and was considered to be in good health and body condition in the months leading up to referral.

On presentation the dog had slightly limited shoulder extension, no gait abnormalities when walking, a body condition score (BCS) of 4/9 with mild muscle wasting, and a body weight (BW) of 44 kg.[1] No other abnormalities were noted on physical exam, but during the exam the dog began to develop generalized tremors progressing to a grand mal seizure. The dog was taken to the Intensive Care Unit (ICU) and found to be tachycardic and hyperthermic (39.4°C), and was given supplemental O_2 via face mask, 22.7 mg/kg bolus of intravenous (IV) fluids[c] and 0.5 mg/kg IV diazepam[d] once. Serum biochemistry tests at this time showed a hypocalcemia, hyponatremia, hypochloremia, hyperphosphatemia, hyperalbuminemia, hypoglobulinemia, and increased activities of ALP (alkaline phosphatase) and CPK (creatine phosphokinase) (Tables #2, Initial ICU); complete blood cell count and urine analysis were normal. Hypocalcemia was suspected to be the cause of the seizure and the dog was given a 45.5 mg/kg IV bolus of 10% calcium (Ca) gluconate.[e] To distinguish between the two top differentials for the hypocalcemia: primary hypoparathyroidism versus nutritional secondary hyperparathyroidism (NSHPTH), blood was drawn for intact parathyroid hormone (iPTH),

[a] Purina Proplan® Chicken and Rice Adult Dry, St. Louis MO (Diet A) 2009 Purina product guide
[b] Nupro All Natural Dog Supplement®, Nutri-Pet Research Inc, Manalapan, NJ
[c] Lactated Ringer Solution, Butler, Deerfield, IL
[d] Valium injectable, 5 mg/ml, Roche, Nutley, NJ
[e] Calcium Gluconate, 10% Solution, APP Pharm, Schaumburg, IL

ionized Ca (iCa) and vitamin D concentrations as the patient received IV constant rate infusions of Ca gluconate (18 mg/kg/hr), diazepam (0.3 mg/kg/hr) and lactated Ringer's solution (2.5 ml/kg/hr). The blood work performed 2 and 6 hrs post ICU presentation (Table #2; 2 and 6 hr) showed a resolving hypocalcemia (iCa) and hyponatremia but hypokalemia; therefore potassium was added to the fluids at 30 mEq/L. Once the dog was mentally alert and stable, the candidate recommended feeding at resting energy requirement (RER) of 1,196 kcal/d [$=70(BW_{kg})^{0.75}$] using 300 g of canned growth Diet C[f] (306 kcal q6 hr per os) while the most appropriate long term diet could be determined.[2] The dog was fed at RER based on current evidence that an illness factor of one can be applied to most illnesses, and that using higher factors may result in overfeeding.[3]

The patient's problem list by the end of Day1 included seizure activity, hyperthermia and tachycardia, which resolved with seizure control, hypocalcemia (iCa), hyponatremia, hyperphosphatemia, hypokalemia (resolved with fluid therapy), hyperalbuminemia, hypoglobulinemia, increased activities of ALP, CPK and hypovitaminosis D (Tables #2 and 3). Other problems included bilateral shoulder OCD based on radiographs, historical small bowel diarrhea at 11 wks of age (resolved with diet change) and a 5-month history of consuming a presumably nutritionally unbalanced homemade diet given the calcium content in the recipe appeared to be inadequate based on preliminary review.[4] The candidate obtained a detailed diet history (Table #1) from the owner and the nutrient profile of the recipe was reconstructed using computer software[g] to the compare nutrient concentrations with dietary growth recommendations. Several nutrients including Ca and vitamin D concentrations were less than 50% of Association of American Feed Control Officials (AAFCO) minimums and the minimums requirements (MR) set by the National Research Council (NRC) (Table #4).[5,6] NRC MR values do not account for variations in nutrient availability or digestibility whereas AAFCO value are adjusted for average known ingredient interactions. While low globulins and increased phosphorous (P) and ALP activity (Table #2) may be explained by the patient's age, several blood abnormalities were attributed to the nutrient deficiencies of Diet B, i.e., hyponatremia, hypochloremia, hypocalcemia and hypovitaminosis D. The most immediate nutrient of concern, however, was calcium due to the onset of a seizure.

[f] Purina Proplan® Chicken and Rice Puppy Canned, St. Louis, MO (Diet C) 2009 Purina product guide
[g] BalanceIT®, DVM Consulting Inc, Davis, CA

The top differential diagnoses for seizures in a young dog include head trauma and toxins[h] (both ruled out in owner history), idiopathic epilepsy, and in this case, hypocalcemia. Top differential for the hypocalcemia was NSHPTH because the patient's iPTH was high ruling out primary hypoparathyroidism (Table #3), and concurrently, Diet B was Ca and vitamin D deficient (Table #4), both of which contributed to the hypocalcemia. Calcium has many critical roles including teeth and bone formation, but calcium also stabilizes sodium channels in nerve axons and prevents muscle tetany, in part explaining the patient tremors and seizure.[7] Calcium regulation requires the integrated actions of parathyroid hormone (PTH), vitamin D metabolites, and calcitonin. PTH is responsible for continuous control of serum iCa and when serum Ca declines, PTH is secreted causing direct bone resorption of Ca, renal tubular reabsorption of Ca with P excretion. Indirectly, PTH causes increased intestinal absorption of Ca by increasing renal synthesis of calcitriol (active form of vitamin D), which also contributes to Ca resorption from bone; hence hypocalcemia occurs with low PTH in primary hypoparathyroid.[7] Hypocalcemia was particularly concerning in this case because the Ca requirement is high during growth relative to adult maintenance.[5,6] Additionally, studies suggest large breed puppies are more sensitive to the harmful effects of low-calcium diets during growth than other breeds.[8,9]

The diagnosis was secondary nutritional hyperparathyroidism due to consumption of a diet containing only 27% of the calcium recommended by AAFCO during growth.[5,8,9] The iPTH in this patient may have been previously higher but was decreasing at the time of blood sampling due to the IV administration of Ca gluconate prior to and during blood collection for iPTH (Table #3). The half-life of PTH is less than 30 minutes in people and declines in response to Ca administration.[10] In NSHPTH, the serum phosphorous (P) is usually low or normal but was slightly elevated in this patient initially, possibly age-related, but returned to within reference limits on day 3 of hospitalization. Although vitamin D is typically elevated in NSHPTH, in this case the vitamin D was most likely low due to the concurrent dietary deficiency (Table #4).[5] Vitamin D is involved in Ca absorption from the intestines and signs of vitamin D deficiency overlap with those of Ca and P deficiencies, including slowed growth, defective skeletal mineralization, and pathologic fractures and rarely, type I vitamin D-dependent rickets.[11,12] Chronic Ca deficiency can also cause osteopenia. Similarly, a case report describes diffuse

[h] ASPCA Pro. Most common causes of seizures in dogs. 2011. Avail at: https://www.aspcapro.org/resource/most-common-causes-seizures-dogs

osteopenia and myelopathy in a puppy fed a homemade calcium deficient diet.[13] Neither osteopenia nor rickets were seen on radiographs of this patient's forelimbs; however, mandibular radiographs revealed diffuse osteopenia, indicating bone demineralization.

The patient was clinically normal in the days following the seizure (day 1) and BW was stable at 44 kg (BCS 4/9). The dog received IV Ca gluconate until normocalcemia (iCa) was achieved on day 2 (Table #2). The infusion rate of Ca gluconate was reduced by 50% and the patient was transitioned to oral Ca carbonate[i] (2500 mg PO q6 hr) for another 3 days pending the start of an appropriate diet to meet the specific nutritional needs of giant breed growth. On Day 3, the patient's iCa was checked prior to discharge and again 4 days later (24 hr after discontinuing oral Ca Carbonate) and found to be within normal limits (Table #2; day 7). Calcium was a nutrient of concern when choosing a diet for this Ca-deficient, growing giant-breed dog, while also avoiding over supplementation. With adequate concentrations of Ca in the diet, the absolute Ca concentration, rather than Ca:P ratio, has been shown to be most critical in skeletal development of large and giant breed dogs.[10] Diet B was both Ca deficient, and had a low Ca:P ratio (0.7). Diet D[j] recommended by the candidate contained 4.5 g of Ca/Mcal of metabolizable energy (ME). While the dog's blood Ca concentration was normal, several months of adequate calcium intake would be necessary to restore bone mineral content.[12] Diet D was chosen after investigating the literature to determine a concentration of Ca, which could be fed to a giant-breed puppy without contributing to the risk of developmental orthopedic disorders (DOD). The candidate considered the work of Laflamme, which reported normal growth after feeding medium to large breed puppies diets with 3.9-5.7 g Ca/Mcal ME, and the safe upper limit suggested by the NRC (4.5 g Ca/Mcal ME).[6,9] Risk factor for DOD in large-breed puppies are excess Ca intake, rapid growth rates related to energy intake (caloric density and/or food dose) and genetics.[14]

Diet D was chosen for several reasons including having reportedly passed an AAFCO growth feeding trial and contained the recommended concentrations of Ca and P. One other

[i] CVS Calcium Carbonate, 1250 mg tablets, CVS Pharmacy, Woonsocket, RI

[j] Purina Veterinary Diets DRM Canine Dry®, St. Louis, MO (Diet D). 3958 kcal/kg as fed, ME: 24.7% from protein, 39.5% from carbohydrate, 35.8% from fat and a Ca:P ratio of 1.6. Ingredients: Brewer rice, salmon meal, trout, canola meal, animal fat, brewers dried yeast, fish oil, corn oil with taurine, minerals and vitamins. Animal feeding tests using AAFCO procedures substantiate Purina DRM formula provides complete and balanced nutrition for growth in puppies. 2010 Purina product guide

important factor was the patient's history of suspected food hypersensitivity. The dog did have a history of small bowel diarrhea when fed the chicken-based commercial Diet A, or whenever the owner tried to increase the amount of Diet A incorporated into the homemade mixture; hence the owner suspected chicken was the cause of the patient's diarrhea. In the hospital, the dog ate a chicken based growth Diet C because a growth diet without poultry was not available. The candidate decided that based on the extent of the nutrient deficiencies in homemade Diet B, feeding a diet that met the young dog's nutritional requirements took priority over feeding a chicken-free diet short term while in-hospital. The owner's diet history did not include whether or not the diarrhea started immediately after the breeder weaned the dog onto commercial Diet A, which would be suggestive of a food intolerance.[15] Hypersensitivities in dogs are rare, but half will involve both gastrointestinal and dermatologic signs. The patient may have had an adverse food reaction to chicken given a third of food reactions occur in the first year of life, and chicken is a common food allergen in dogs.[15,16] Common allergens in Diet A were chicken, rice, wheat and egg. The homemade Diet B also contained rice and egg, but no wheat or chicken, which made wheat or chicken the more likely allergens if diarrhea was due to an adverse food reaction. Preservatives rarely cause adverse food reactions, but if so, the patient would be expected to have diarrhea when fed commercial Diet D as well.

Although possibly due to the abrupt diet change, hyperthermia, or stress of seizing, the dog did have loose stool (fecal score 6/7)[k] on growth diet C that contained chicken while in the hospital. Confirmation of an adverse food reaction would require an elimination diet trial for 3-12 wks while feeding a novel protein and carbohydrate, or a hydrolyzed protein diet, followed by refeeding the original diet and a subsequent return of clinical signs.[16,17] While not a true elimination diet trial because Diet D contained rice, a plausible allergen in Diet A, the diet did avoid chicken and wheat. The candidate emphasized to the owner that while the diarrhea resolved with a diet change at 11 wks old, the clinical signs may not have been diet-related, and if diarrhea recurs, further diagnostics would be indicated. Other possible causes of diarrhea in this young dog included stress of shipping and/or infectious and the resolution with a diet change was coincidental. The Candidate addressed the possibility of food allergy because of the concern that the owner may resort to an unbalanced homemade diet if diarrhea returned on the

[k] Greco, DS. Diagnosing Gastrointestinal Disease. Nestlé Purina Fecal Scoring System. 2010 p11 Available from: https://www.purina.it/veterinari/system/.../1_Diagnosing_Gastrointestinal_disease.pdf

recommended diet. Diet D contained rice but was chosen over other novel-protein and hydrolyzed diets approved for growth because Diet D met AAFCO growth requirements and provided adequate concentrations of the nutrients of concern (Ca, P, vitamin D and taurine) for this giant breed patient.[5]

One other nutrient of concern of this patient was taurine based on research showing a link between low blood taurine concentrations and dilated cardiomyopathy (DCM) in some giant breeds and the suggestion that these dogs may have a higher dietary requirement. [18,19] Diet B contained low or no taurine based on the ingredient list but did contain adequate methionine and cystine concentrations, which are utilized in taurine synthesis (Table #4). Taurine concentrations in the dog were tested and an echocardiogram was performed due to breed susceptibility to such a deficiency. The echocardiogram results were within normal limits; however plasma and whole blood taurine concentrations in this patient were low (Table #5). The dog was started on an oral taurine product[l] (500 mg q12 hr).[18,20] While the most common sign of taurine deficiency in dogs is DCM, taurine has many other roles, and the dog was initially supplemented for 4 wks until whole blood taurine could be rechecked. Whole blood taurine concentration, not affected by feeding as is plasma taurine, was found to be adequate after 4 wks of supplementation (Table #5). The taurine supplement was discontinued because the taurine concentration in Diet D was calculated to be equivalent (1g/day) (Fig #1) to the supplementation.

Homemade Diet B was also deficient in several other nutrients (Table #4) but the dog did not exhibit any obvious clinical signs of these nutritional deficiencies: vitamin A (nyctalopia, xerophthalmia), iron (microcytic hypochromic anemia), copper (hypochromic anemia, poor coat pigmentation) or linoleic acid (dry skin/skin lesions). Perhaps if more sensitive testing, such as blood vitamin A or total Fe-binding capacity, had been performed, subclinical deficiencies may have been identified. Given the owner had agreed to feed a diet adequate for growth, Diet D, and due to the lack of clinical signs and financial constraints, these additional tests were not performed. Although many nutrients in Diet B were well below AAFCO requirements for growth, these concentrations were not all below dietary minimum requirement set by the NRC.[5,6] AAFCO values were used for diet comparisons because these values are practical minimums formulated from non-purified ingredients, although nutrients of concern, such as Ca, Vitamin D, and P were below NRC MR as well.[6]

[l] Taurine, 250 mg tablets, PetAg Inc, Hampshire, IL

The candidate reviewed with the owner common nutritional deficiencies (trace minerals, vitamins) associated with feeding unbalanced homemade diets (Table #4) and the benefits of feeding a complete and balanced commercial diet or a homemade diet formulated by a veterinary nutritionist.[6] The candidate also explained that feeding adult diets to puppies in order to avoid the excessive calorie and Ca intake negatively associated with DOD, overlooked the other different nutrient requirements of puppies including higher requirements for Ca, P, iron and protein. Additionally, when these puppies consume larger quantities of lower calorie adult diets to meet daily energy needs, the animal is consuming excessive Ca (g/kg BW), which is a risk factor associated with DOD. The candidate also pointed out that feeding excess calories does put puppies at risk for DOD when BCS >6/9 and that diets designed for large-breed puppies avoid excess calorie intake when fed at an appropriate dose.[14] Although the exact concentrations of Ca, P, vitamin D and caloric content of large breed growth diets are debated, the candidate explained that based on the most recent literature, monitoring BCS while feeding a diet formulated to meet nutrients requirements was advisable to ensure optimal, not maximal growth, until 90+% of adult size had been achieved.[21,22] In this patient diagnosed with OCD, a type of DOD, avoiding excess weight may minimize pain and future osteoarthritic changes. The owner agreed to feed commercial Diet D exclusively, no added human or pet foods, supplements, or treats other than hydrolyzed biscuits[m] prescribed training (<14 day or <10% of daily kcals), and to only use unflavored heartworm preventative and toothpaste. The dog was also started on a unflavored glucosamine hydrochloride/chondroitin sulfate supplement[n] (450 mg/capsule) dosed as recommended based on BW for chondroprotective effects.[23,24]

Given the dog was in good body condition (4/9) at initial presentation, the daily caloric intake on Diet B [2068 kcal/day = 1309 g x 1.58 kcal/g (Table #1)] was used as a starting point for Diet D. The dog was weighed and BCS was assessed weekly at the teaching hospital for 2 months, and feeding adjustments were made to ensure lean, optimal growth until achieving approximately 90% of adult BW (Table #6). The candidate spoke with the owner weekly (by phone or in person) to ensure the dog was not experiencing any of the original clinical signs (diarrhea, abnormal behavior or seizures). This case highlights the importance of obtaining a nutritionally balanced recipe when owners choose to feed homemade diets to their pets.

[m] Purina Gentle Snackers®, St. Louis, MO (hydrolyzed dog biscuit)
[n] Cosequin Regular Strength Capsules®, Nutramax Laboratories, Edgewood, MD

218 References:

[1] Laflamme DP. Development and validation of a body condition score system for dogs: A clinical tool. Canine Practice - Nutrition. 1997;22(4):10-15.

[2] Kleiber M. The Fire of Life. New York: John Wiley & Sons, 1961.

[3] Walton RS, Wingfield WE, Ogilvie GK, et al. Energy expenditure in 104 postoperative and traumatically injured dogs with indirect calorimetry. J Vet Emerg Crit Care. 1996;6:71-9.

[4] Remillard RL, Crane SW. Small Animal Clinical Nutrition. 5th ed. Topeka, KS: Mark Morris Institute; c2010. Chapter 10, Making Pet Foods at Home; p. 207-223.

[5] Association of American Feed Control Officials Incorporated. AAFCO Official Publication. c2009. Chapter 4, Model Regulations for Pet food and Specialty Pet food Under the Model Bill: p.150-151.

[6] National Research Council. Ad hoc Committee on Dog and Cat Nutrition. National Research Council Nutrient Requirements of Dogs and Cats. Washington DC: The National Academies Press; 2006. Table 15-3, Nutrient Requirements for Growth of Puppies after Weaning; p.357-358.

[7] Nelson RW. Textbook of Veterinary Internal Medicine. 7th ed. St. Louis: Elsevier Saunders; c2010. Parathyroid Hormone; p. 668-669.

[8] Nap R, Hazewinkel HW, Van den Brom W. Calcium kinetics in growing miniature poodles challenged by four different dietary levels of calcium. J Nutr. 1993;123:1826-1833.

[9] Laflamme, D. Effect of breed size on calcium requirements for puppies. Compend Contin Educ Pract Vet. 2000;23:66-69.

[10] Aurbach GD, Potts JT. Parathyroid hormone. Am J Med. 1967 Jan;42(1):1–8.

[11] Hazewinkle HW, Van den Brom W, Van't Klooster A, et al. Calcium metabolism in Great Dane dogs fed diets with various calcium and phosphorus levels. J. Nutr. l991; 121 (suppl); 99S-1106S.

[12] Malik R, Laing C, Davis PE, et al. Rickets in a litter of racing Greyhounds. J Sm Anim Pract. 1997;38:109-114.

[13] Taylor MB, Geiger DA, Saker KE, et al. Diffuse osteopenia and myelopathy in a puppy fed a diet composed of an organic premix and raw ground beef. J Am Vet Med Assoc. 2009;234(8):1041-1048.

[14] Slater M, Scarlett J, Donoghue S, et al. Diet and exercise as potential risk factors for osteochondritis dissecans in dogs. Am J Vet Res. 1992;53:2119-2124.

[15] Roudebush P, Guilford WG, Jackson HA. Small Animal Clinical Nutrition. 5th ed. Topeka, KS: Mark Morris Institute; c2010. Chapter 31, Adverse Food Reactions; p. 610-619.

[16] Rosser EJ. Diagnosis of food allergy in dogs. J Vet Med Assoc. 1993;203:259-2.

[17] Verlinden A, Hesta M, Millet S, et al. Food Allergy in Dogs and Cats: A Review. Crit. Rev. Food Sci. Nutr. 2006;46:259–273.

[18] Fascetti AJ, Reed FR, Rogers QR, et al. Taurine deficiency dilated cardiomyopathy in dogs. J Am Vet Med Assoc. 2003;223:1137-1141.

[19] Backus BC, Kwang SK, Fascetti AJ, et al. Low plasma taurine concentration in Newfoundland dogs is associated with low plasma methionine and cysteine concentrations and low taurine synthesis. J Nutr. 2006;136:2525-2533.

[20] Bragg RR, Freeman LM, Fascetti AJ, et al. Composition, disintegrative properties, and labeling compliance of commercially available taurine and carnitine dietary products. J Am Vet Med Assoc. 2009;234(2): 209-213.

[21] Hawthorne AJ, Booles D, Nugent PA, et al. Changes in bodyweight of puppies of different breeds during growth. J Nutr. 2004;134:2027S-2030S.

[22] Meyer H, Zentek J. Influence of various levels of energy intake in growing Great Danes on growth intensity and skeletal development. J Vet Med. 1992;A39:130-141.

[23] Consumer Laboratory Website. Product review: Joint supplement (glucosamine and chondroitin). Avail. at www.consumcrl3bs.com,..rcsultsitduco.asp. Accessed May 5, 2010.

[24] Neil K, Caron J, Orth M. The role of glucosamine and chondroitin sulfate in treatment for and prevention of osteoarthritis in animals. J Am Vet Med Assoc. 2005;226:1079-88.

Table #1. Homemade Diet B composition and daily amounts for the 8 month old dog

Ingredient	USDA NDB#*	Amount consumed/day	Amount consumed g/d†
Beef ground, 90% lean meat/10% fat crumbles cooked pan-browned	23565	2 lbs	908
White, long grain, rice, enriched, cooked	20045	1.5 cups	237
Apple, raw with skin	09003	0.5 med size	91
Broccoli, cooked	11740	0.33 cup	24
Egg, whole, large, raw with shell‡	01123	0.43 egg	9
NuPro Canine supplement (5 g/scoop)		2 scoops	10
Purina Proplan® Chicken and Rice Puppy		0.33 cup	30
Total			1309$

* USDA National Food Composition Database https://ndb.nal.usda.gov/ndb

† Dry matter 35.6%; 1.58 kcal/g as fed

‡ Shell ($CaCO_3$) is 13% of whole egg weight

$ Consuming 1309 g/d x 1.58 kcal/g as fed = MER = 2068 kcal/d at presentation

Table #2. Chemistry Profiles by Hospital Admit*†

Test (units)	Reference Range	Initial ICU	2 hours	6 hours	Day 2	Day 7
BUN (mg/dL)‡	12.0-28.0	21	24		10	13.0
Creatinine (mg/dL)	0.2-2.1	0.9	1.0		0.8	0.9
ALP (U/L)†	12-127	**181**				
ALT (U/L)‡	17-86	30				
AST (U/L)‡	9-54	48				
CPK (U/L)‡	22-422	**453**				
GGT (U/L)‡	0-10	5				
Total Bilirubin (mg/dL)	0.1-0.3	0.2				
Amylase (U/L)	409-1250	473				
Glucose (mg/dL)	67-135	123	99	113	111	116
Sodium (mEq/L)	140-150	**134.6**	**137.6**	**139.5**	142.7	144.0
Potassium (mEq/L)	3.7-5.4	3.8	**3.4**	**3.3**	4.0	4.1
Chloride (mEq/L)	106-116	**98**	**101**	106	115	110
Calcium (mg/dL)	9.4-11.8	**7.7**				
Ionized Ca (mg/dL)	1.2-1.4	**0.8**	**1.01**	**1.05**	1.2	1.2
Phosphorous (mg/dL)	2.6-7.2	7.9				
Magnesium (mg/dL)	1.8-2.6	1.8				
Total Protein (g/dL)	5.5-7.8	6.4				
Albumin (g/dL)	2.8-4.0	**4.4**				
Globulin (g/dL)	2.3-4.2	**2.0**				
Cholesterol (mg/dL)	82-355	322				
pH	7.33-7.47	7.47	7.46	7.5	7.4	7.4
HCO_3 (mmol/L)	18-24	24.5	19.8	22	16.1	20.2
Total CO_2 (mEq/L)	14-28	25.4	20.6	22.9	16.9	21.1

* Blanks are tests not done

† Bolded values are outside the normal range

‡ Blood urea nitrogen (BUN); alkaline phosphatase (ALP); alanine aminotransferase (ALT); aspartate aminotransferase (AST); creatine phosphokinase (CPK); gamma-glutamyl transferase (GGT)

Table #3. Parathyroid Panel Results during ICU Treatment for Seizure*

Test (units)	Normal values	Day 1†
Intact Parathyroid Hormone (pmol/L)	0.5-5	**9.1**
Vitamin D (mmol/L)	60-215	**18.0**
Ionized Calcium (mmol/L)	1.2-1.45	**1.1**

* Bolded values are outside normal range

† Sample collected after receiving one bolus of IV Ca gluconate and while on Ca gluconate continuous rate infusion

Table #4. NRC and AAFCO Canine Growth Nutrient Recommendations Compared with Homemade Diet B* *Editorial note: Diet D nutrient profile should have been included.*

Nutrient (units per Mcal)	NRC MR	AAFCO Minimums	Homemade Diet B
Protein (g)	35	62.9	96.94
Arginine (g)	1.33	1.77	6.25
Histidine (g)	0.50	0.63	2.87
Isoleucine (g)	1.0	1.29	4.13
Leucine (g)	1.63	2.06	7.21
Lysine (g)	1.40	2.20	7.43
Methionine + Cystine (g)	1.05	1.51	3.28
Phenylalanine + Tyrosine (g)	2.00	2.54	6.52
Threonine (g)	1.25	1.66	3.5
Tryptophan (g)	0.35	0.57	0.42
Valine (g)	1.13	1.37	4.62
Crude Fat (g)	21.3	22.9	47.99
Linoleic acid (g)	3.0	2.9	**1.78**
Calcium (g)	2.0	2.9	**0.79**
Phosphorus (g)	2.5	2.3	**1.13**
Potassium (g)	1.1	1.7	1.66
Sodium (mg)	550	860	370
Chloride (mg)	720	1290	10†
Magnesium (mg)	45	110	170
Iron (mg)	18	23	**13.22**
Copper (mg)	2.7	2.1	**0.68**
Manganese (mg)	1.4	1.4	**0.75**
Zinc (mg)	10	34	22.65
Iodine (ug)	220	430	80†
Selenium (ug)	52.5	30	90
Vitamin A (RE)	303	433	**34.7**
Vitamin D (ug)	2.75	3.57	**0.02**
Vitamin E (mg)	6.0	14	10.21
Thiamine (mg)	0.27	0.29	54.25
Riboflavin (mg)	1.05	0.63	3.19
Pant Acid (mg)	3.0	2.9	3.58
Niacin (mg)	3.4	3.3	23.98
Pyridoxine (mg)	0.3	0.29	2.35
Folic acid (ug)	54	50	**0.17**
Vitamin B_{12} (ug)	7	6	10
Choline (mg)	340	343	327†
Taurine	NR‡	NR	350†

* Bolded values are below NRC Minimum Requirements (MR)

† Minimum value from supplement because nutrient is not known in USDA Food Database.

‡ No Recommendation (NR)

Table #5. Patient Taurine Concentrations*

Test (nmol/ml)	Reference Range	Day 3 of Hospitalization	After 4 weeks Of supplementation
Whole blood Taurine	200-350	**160**	408
Plasma Taurine	60-120	**29**	Did not retest

* Bolded values are below normal limits

Figure #1. Calculation of Diet D taurine concentrations

- Taurine 0.19% DMB = 0.0019 x 90% DM = 0.17% as fed
- Taurine = 0.17 g/100 g as fed = 1.7 g/kg diet
  = (1.7 g/kg) / (3958 kcal/kg) = 0.00043 g/kcal of diet
  = 0.43 mg/kcal of diet or 430 mg/Mcal of diet
- Dog consuming 2528 kcal/day = 1087 mg taurine/d

Table #6. Weight gain, body condition and daily energy requirement following hospital discharge

	Weeks*								
Assessment	0	1	2	3	4	5	6	7	8†
Body Weight Kg	44.0	44.7	45.5	46.1	47.8	48.6	49.2	49.5	51.0
Body Condition Score (1-9)	4	4	4	3	4	4	4	3	4
Muscle condition score‡	mild	mild	mild	none	none	none	none	none	none
Kcal ME/d of Diet D fed	2069	2068	2167	2265	2528	2528	2528	2528	2724

* Weeks after hospital discharge

† Dog is 10 months old

‡ WSAVA. Muscle Condition Score. Muscle condition score - a new tool for patient assessment, 2013. Avail at: www.wsava.org/sites/default/files/Muscle%20condition%20score%20chart%202013.pdf.