

RENAL FAILURE ASSOCIATED WITH METASTATIC MINERALIZATION OF THE KIDNEYS IN BIRDS

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INTRODUCTION

Metastatic mineralization of the kidneys occurs sporadically in cage birds (Phalen, 1990). Uncommonly, clusters of cases will be seen in an aviary (Phalen, 1991, unpublished data). Metastatic mineralization may occur in the kidneys alone or accompany metastatic mineralization of other organs, most commonly the proventriculus and the ventriculus. Metastatic mineralization is the result of a persistent hypercalcemia. There are several possible causes for hypercalcemia and the resulting metastatic mineralization of the kidneys and other organs. Multiple lorikeets died with lesions including kidney mineralization after being fed a diet containing a very high concentration of vitamin D₃ as the result of a formulation error (West G, pers comm, 1997). Studies have also shown that vitamin D₃ can be toxic to chickens, however, concentrations an order of magnitude or higher than those found in poultry feeds were necessary to cause toxicity (Siller, 1981). Rat baits containing vitamin D₃, if eaten by birds, would have the same impact as massive doses of dietary vitamin D₃. Roosters fed laying pellets containing 1.5% calcium will develop metastatic mineralization of the kidneys, suggesting that high concentrations of dietary calcium alone can result in renal metastatic mineralization (Siller, 1981). Lastly, renal metastatic mineralization is seen in animals poisoned with cadmium (Hooser, 2007). It would be very unlikely, however, for cage birds to be exposed to cadmium.

This study was triggered by a sudden onset of mortality in a budgerigar aviary where the predominate lesion found was metastatic mineralization of the kidney. The owner had recently converted his birds onto a diet formulated for growing pheasants. The diet contained both relatively high concentrations of calcium (1.0%) and vitamin D₃ (1,500IU/kg) (Roset et al., 2000). In this manuscript, the results of a controlled feeding trial in budgerigars where calcium and vitamin D₃ were varied are reported. Also reported are the incidence of renal metastatic mineralization in diagnostic samples submitted to the Wildlife Health and Conservation Centre Avian Diagnostic Service during the period from January 2008 to August 2009.

MATERIALS AND METHODS

Budgerigar nutrition trial

Twelve diets were generated for this research. Three concentrations of calcium (0.3%, 0.7% and

1.5%) were used. For each concentration of calcium, diets containing four concentrations of vitamin D₃ (500 IU/kg, 1000 IU/kg, 2000 IU/kg and 3300 IU/kg) were formulated. The phosphorus concentration was held constant at 0.7%. Each diet contained 4% fat and 16% protein. Ten pairs of birds were fed each diet. Five pairs were fed each diet for 1 year and five pairs were fed the diet for 2 years. The breeding birds used in the two year study were housed in group cages containing 5 pairs of birds per treatment group and allowed to produce 3 clutches of chicks in the first and second breeding season. The breeding birds used in the one year study were housed as individual pairs, in order to prevent aggression that occurred in the gang-caged birds. These birds were allowed to produce 3 clutches of chicks. During the first year of the study, nestlings were collected at 24 and 31 days of age. During the second year of the study nestlings were collected at 12 and 24 days of age. Adults were collected after the final breeding cycle.

Proventriculus, ventriculus, and kidney were examined microscopically for metastatic mineralization. The parathyroids were examined microscopically for evidence of hypertrophy and hyperplasia. Bone was examined for evidence of fibrous osteodystrophy in adult birds and rickets in nestlings. Five representative tissue sections containing metastatic mineralization were stained with a Von Kossa's stain for calcium.

Microscopic sections were considered positive if any degree of metastatic mineralization was seen and negative if it was not. The degree of metastatic mineralization was also given a severity score of 1 (mild), 2 (moderate) and 3 (severe). The number of positive and negative birds and the scores between groups were compared using the Chi-square test of independence and were considered significantly different at $p \leq 0.05$.

Prevalence in diagnostic submissions

A total of 80 formalin-fixed sets of tissues that included kidney samples were submitted between 1 January 2008 and 1 September 2009 to the diagnostic service of the Wildlife Health and Conservation Centre, University of Sydney. Of these cases, 32 were samples from pigeons.

RESULTS

Nestling budgerigars

Rickets and parathyroid changes were not seen in the nestling birds on any of the prepared diets. Histologically, normal bone formation was found in all the chicks on pelleted diets.

Metastatic mineralization was not seen in chicks being fed the diets 0.3% calcium. Metastatic mineralization was seen in 28 day-old nestlings of all treatment groups with calcium concentrations of 0.7% (40-54% of the chicks) and 1.5% (67-92% of the chicks). The metastatic mineralization was mild to moderate in the chicks fed the 0.7% calcium diet, but was severe, often resulting in renal failure in the chicks on 1.5% calcium diets. Chicks on the 1.5% calcium diets were often stunted and many died spontaneously. Chick production was significantly lower in these treatment groups. Metastatic mineralization was significantly more common in chicks fed diets containing 0.7% calcium as compared to 0.3% calcium. The number of positive chicks and the severity of their lesions was significantly higher in birds on a 1.5% calcium diet as compared to chicks on a 0.7% calcium diet.

In the second year, tissues were examined from younger chicks (14 days old). Metastatic mineralization was significantly reduced in these birds, suggesting that soft tissue mineralization did

not begin to occur until the end of rapid bone growth.

Vitamin D₃ concentrations had no impact on the presence, or degree of, metastatic mineralization in the nestlings in year one. A slight additive effect may have occurred in diet 11 and 12 the diets containing the highest concentration of calcium and vitamin D₃ as these chicks were slow to develop and grew poorly as compared to chicks on the high calcium diets that contained less vitamin D₃.

Metastatic mineralization was most severe in the kidneys of the chicks that died spontaneously. In these birds there was evidence of renal failure with the formation of intra-renal urate tophi. Metastatic mineralization of the ventriculus also occurred, but less frequently. Metastatic mineralization of the proventriculus was not seen.

Adult budgerigars

Bone lesions were not found in male or female birds. Slight hypertrophy of parathyroid gland was seen in some of the breeding birds on the 0.3% calcium diets. Bone changes, however, were not noted. Metastatic mineralization of soft tissues was not observed in these birds.

Metastatic mineralization of the kidney was found to occur in approximately 50% of all birds, male and female, on diets that contained 0.7% and 1.5% calcium. Lesion scores for birds that were fed these diets for one year were similar to those of birds that were fed these diets for 2 years. Vitamin D₃ concentrations did not affect the lesions scores.

Considerable mortality occurred in all treatment groups, with the leading cause of death being aggression. However, examination of some of the birds fed the high calcium diets that died spontaneously suggested that metastatic mineralization of the kidneys may have contributed to some of the birds' deaths. Two birds on the high calcium and highest vitamin D₃ diet developed renal failure and gout.

Metastatic mineralization of the proventriculus was uncommon and occurred only in the diets that contained 1.5% calcium. Metastatic mineralization of the ventriculus was rare.

All five sections stained with Von Kossa's stain were positive for calcium.

Histologic analysis of the tibiotarsus revealed a marked difference between the bone of the male bird and the bone of the female bird. In the male bird, the cortex had a consistent thickness and there were few intra-medullary trabeculae. In the hen, there were varying degrees of medullary bone formation resulting in cortex thickening and the development of an extensive network of trabeculae. The volume of medullary bone correlated with the reproductive activity of the hen and not the treatment group. The exception to this observation was the absence of medullary bone and the fibrous osteodystrophy in the hens fed the all seed diet.

Prevalence in diagnostic submissions

Renal metastatic mineralization was identified 10 out of 80 (12.5%) of the submissions. Species with these lesions were 2 nestling Amazon parrots, a nestling king parrot, a nestling cockatiel, a nestling eclectus parrot, a chicken, and four pigeons. The four pigeons represented 13.2% of the pigeon samples examined. The degree of the lesion varied from mild to severe. Urate nephrosis was seen in one bird. Concurrent disease, unrelated to the renal lesions, was seen in 7 of 10 birds. The renal

mineralization was considered the cause of death in 3 birds (an eclectus parrot and 2 pigeons). A single case of metastatic mineralization of the koilin but not the kidney was found in a cockatiel chick. Detailed histories on these birds were not available, but at least one of the pigeon flocks with birds with metastatic mineralization were feeding alfalfa based pellets.

CONCLUSIONS

Studies show that in domestic birds a 1:1 ratio of calcium to phosphorus and at least 0.7% calcium in the diet is necessary for young birds to properly form bone (Lesson and Summers, 1997). In past studies, it has been assumed that metastatic mineralization seen commonly in cage birds is the result of over supplementation of vitamin D₃ (Takeshita et al., 1986). The results of this study clearly demonstrate that this is not the case for the budgerigar.

Instead, his work shows that diets with 0.7% phosphorus and 0.7% calcium or greater will result in metastatic mineralization of soft tissues in both nestling and adult budgerigars and diets containing 1.5% calcium were clearly toxic to nestlings and to a lesser extent adult birds. This is highly significant given that none of the commercial nestling hand feeding diets available at the time of this study contained less than 0.7% calcium and most contained more than 0.7% calcium. In contrast, vitamin D₃ concentrations had little or no impact on the prevalence or severity of metastatic mineralization. Indicating that budgerigars can be safely fed diets containing anywhere from 500 - 2,000 IU/kg and probably diets with as much as 3,300 IU/kg.

A second objective of this study was to determine the minimum requirement for calcium and vitamin D₃. It was expected that the 0.3% calcium and 500 IU/kg vitamin D₃ diet would induce rickets in the nestling birds and that laying hens would have developed an osteodystrophy. In fact, the birds on this diet did as well or better than birds on any other diets. These results suggest that the budgerigar and perhaps other species of birds whose diets, in the wild, are relatively deficient in calcium have developed a mechanism to efficiently scavenge calcium from their food. We hypothesize that this is why higher calcium diets are so toxic to them. We postulate that these birds do not down regulate calcium uptake when confronted with a calcium rich diet and absorb more than they can efficiently excrete. A trend toward higher calcium concentrations in the plasma of adult birds on the calcium rich diets suggests that the metastatic mineralization observed in these birds may be the result of high plasma calcium concentrations.

These results indicate that a safe and adequate diet for adult and nestling budgerigars contains 0.7% phosphorus, 0.3% calcium and a minimum of 500 IU/kg vitamin D₃ and calcium concentrations of 0.7% or higher are toxic to the budgerigar. These findings may also relate to other species of parrots such as the cockatiel and to insectivorous species of birds. However, extreme care must be used in applying these data to other species of birds. The budgerigar and other species of birds in which metastatic mineralization has been observed may be the exceptions and not the rule. In other species of birds higher calcium requirements are most likely necessary and the optimum budgerigar diet is likely to be inadequate for them.

The prevalence of metastatic mineralization in necropsy specimens from the Wildlife Health and Conservation Centre case load was not trivial and was significantly higher than that reported in a previous study in the United States. The lesions in parrots were all in hand-fed nestlings, raising the possibility that hand feeding diets containing excess calcium may be the cause of them. The history of one flock of pigeons with this disease being fed Lucerne based pellets also suggests that excess dietary calcium may be the aetiology of the lesions seen in pigeons. Practitioners should consider

calcium toxicity as a differential in parrot flocks exhibiting increased mortality in hand-fed chicks and in pigeons, particularly if sick birds are exhibiting signs of renal disease.

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