Journal of Zoo and Wildlife Medicine 35(2): 185–196, 2004

TRAUMA-INDUCED ANEURYSMAL BONE CYSTS IN TWO PSITTACINE SPECIES (*CACATUA ALBA* AND *NYMPHICUS HOLLANDICUS*)

J. Jill Heatley, D.V.M., M.S., Dipl. A.B.V.P. (Avian), Thomas N. Tully, Jr., D.V.M., M.S. Dipl. A.B.V.P. (Avian), Dipl. E.C.A.M.S., Mark A. Mitchell, D.V.M., Ph.D., Beth P. Partington, D.V.M., M.S., Dipl., A.C.V.R. and H. Wayne Taylor, D.V.M., Ph.D., Dipl. A.C.V.P.

Abstract: An umbrella cockatoo (*Cacatua alba*) and two cockatiels (*Nymphicus hollandicus*) were presented with rapidly enlarging masses of the head or wing joints. Historic trauma to these areas was confirmed in two cases. All birds were >2 yr of age, and two were female. Cytologic examination of fluid aspirated from masses in two cases was described as serosanguineous cytologically but failed to reveal inflammation, neoplasia, or microorganisms. Radiographic evaluation of these masses included proliferation and lysis of bone, suggestive of a neoplastic process. Histopathologic examination of surgically excised tissues revealed proliferative new bone and an absence of neoplastic tissue in all cases, consistent with aneurysmal bone cyst formation. Despite the guarded prognosis reported for other companion animals, these case results suggest a good prognosis for aneurysmal bone cyst in psittaciformes. Complete surgical excision and histopathologic examination is recommended for definitive diagnoses of aneurysmal bone cyst. Postoperative bandaging and rational antibiotic use are indicated to prevent excessive motion and secondary infection of affected sites, respectively.

Key words: *Cacatua alba*, *Nymphicus hollandicus*, trauma, aneurysmal bone cyst, psittacine.

INTRODUCTION

Aneurysmal bone cysts are expansile cortical bone lesions likely resulting from anomalous vascular processes of bone marrow. Primary aneurysmal bone cysts lack an apparent cause, whereas secondary bone cysts are associated with an underlying disease process such as neoplasia. In humans, diagnoses of aneurysmal bone cysts are based on radiographic and histopathologic findings; primary therapies include excision with bone grafting.[14] Aneurysmal bone cysts are rare in animals. Although their prognosis in humans is generally good, it is guarded to grave in domestic animals.[3,5,7,16,18,19,21] However, we describe three cases of aneurysmal bone cyst, with favorable outcomes in two psittacine species.

CASE REPORTS

Case report 1

An adult cockatiel (*Nymphicus hollandicus*) of unknown sex was presented for a cranial mass, which had enlarged over a 12-mo period. The bird had been housed with a group of cockatiels in a free-flight aviary and offered a free-choice commercial seed mix diet. It was reported that the bird had flown into a window approximately 1 yr before presentation. Physical abnormalities were limited to a featherless mass (1.0 × 1.0 × 0.25 cm) on the superior aspect of the cranium, with a hardness consistent with bone and no signs of pain or inflammation. Based on the physical examination and the size and placement of the mass, a poor prognosis for clinical resolution of the presenting condition was given. The bird was then donated to The Louisiana State University Veterinary Teaching Hospital for surgical removal of the mass.

The bird was anesthetized with isoflurane (Isoflo®, isoflurane USP, Abbott Laboratories, North Chicago, Illinois 60064, USA) in oxygen administered by face mask. An elliptical skin incision was made over the mass, and the skin and subcutis were bluntly dissected free from the underlying mass (Fig. 1). Removal of the superficial layer of the mass exposed a cystic structure (Fig. 2) containing serosanguineous fluid, which was aspirated using sterile technique but not cultured. The remaining walls of the bone cyst were debrided to the cranium, which formed the base of the mass (Fig. 3), and were submitted for histopathologic evaluation. The skin was closed with a 4-0, synthetic, absorbable, monofilament suture (PDS II, Ethicon©, Somerville, New Jersey 08876, USA) in a simple interrupted suture pattern (Fig. 4). Histopathologic findings were consistent with aneurysmal bone cyst. No recurrence of the mass was evident for 24 mo after the surgical procedure.

From the Departments of Clinical Sciences (Heatley, Tully, Mitchell, Partington) and Pathobiology (Taylor), School of Veterinary Medicine, Louisiana State University, Baton Rouge, Louisiana 70803-8410, USA. Present address (Heatley): Department of Clinical Sciences, College of Veterinary Medicine, Auburn University, Alabama 36849, USA. Correspondence should be directed to Dr. Heatley.

Figure 1. Intraoperative elliptical incision exposing the mass on the dorsocaudal aspect of the head of a cockatiel.

Case report 2

A 15-yr-old, 95-g female cockatiel was presented for a featherless, immobile, s.c. nodular mass (1.0 × 1.0 × 0.5 cm) of 45-day duration on the ventral left metacarpus. The bird was maintained indoors in a standard cockatiel cage and fed a commercial seed mix for cockatiels. The owner was concerned that the mass had enlarged since first detection and now affected the bird's ability to fly. On further examination, a similar but smaller mass of 0.5 × 0.5 × 0.25 cm was noted in the same location on the contralateral wing. Other abnormal findings on physical examination were limited to a palpable mass in the caudal coelom, consistent with an egg.

Initial diagnostics were limited to a complete blood count (CBC) and radiography of the wings. Abnormal CBC findings were a mild leukocytosis (12,300 cells/μl, reference range: 5,000–11,000) with a heterophilia (10,800 cells/μl, reference range: 2,300–7,000), lymphocytopenia (500 cells/μl, reference range: 1,250–6,600), and gross plasma that appeared lipemic and yellow.[6,9] Abnormal radiographic findings included extracortical mineralization of the soft tissues associated with the metacarpal bones of both wings (Figs. 5, 6). The distal cortex of each metacarpal bone appeared intact, and radiographic interpretation concluded that these findings were consistent with cutaneous exostosis.

The animal was anesthetized with isoflurane in oxygen administered by face mask. The left-wing mass was biopsied by sharp excision under general anesthesia. Postoperatively, doxycycline (Vibramycin SF I.V., Pfizer Inc., New York, New York 10017, USA; 50 mg/kg, i.m., once) was administered. Histopathologic findings included infiltration of the s.c. fat with focal accumulations of well-differentiated, haphazardly arranged spicules of laminar bone and numerous red blood cells. No histologic evidence of neoplastic bone formation was found, but recent trauma was considered, based on a lack of inflammatory cells in the sections examined. Based on these findings, bilateral surgical cyst excision and curettage of the remaining cortices was performed in a second surgery. A figure-of-eight bandage was placed on each wing postoperatively, and the owner was instructed to provide cage rest until reexamination.

Figure 2. Exterior shell of the aneurysmal bone cyst of a cockatiel before incision.

At this reexamination and bandage change 7 days postoperatively, complications of s.c. hematoma and edema were noted on the ventral left metacarpus at the surgical site. The right wing had healed without complications. A figure-of-eight bandage was replaced on the left wing only, and cage rest was continued for an additional 7 days. At reexamination 14 days postsurgically, both wings had developed healthy granulation tissue at the incision sites. Bandaging was discontinued, and the owner was instructed to apply a light coating of an over-the-counter multiple antibiotic ointment topically to each site once daily to avoid secondary bacterial infection and to promote reepithelialization of the incision sites. The owner failed to return for further follow-up care.

Case report 3

A 2-yr-old, 604-g umbrella cockatoo (*Cacatua alba*) presented for a swelling of 1-mo duration in the ventral proximal antebrachium of the right wing. The owner attributed the mass to a fall the bird sustained in the cage approximately 3 mo before presentation. The owner reported no signs of pain associated with the mass but reported that the mass had increased in size during a 1-mo period. Abnormal physical examination findings were limited to a 4.0- × 4.0- × 1.0-cm, firm, nonfluctuant, uninflamed mass found on the ventral surface of the right wing at the humeroradioulnar joint.

The initial diagnostic plan included a CBC, plasma biochemical analysis, fine-needle aspiration of the mass, and whole-body radiographs. Hematologic abnormalities included leukocytosis (20,400 cells/μl, reference range: 8,000–16,000 cells/μl) with a heterophilia (16,300 cells/μl, reference range: 3,600–11,360 cells/μl), lymphopenia (1,000 cells/μl, reference range: 0–320 cells/μl), monocytosis (3,100 cells/μl, reference range: 1,600–8,160 cells/μl), anemia (packed cell volume 26%, reference range: 38–48%), an elevated alkaline phosphatase (218 IU/L, reference range: 38–106), and a hypouricemia (35.7 μmol/L, reference range: 208.2–648.3).[1,6,9] Cytologic evaluation of the fine-needle aspirate of the mass revealed low numbers of erythrocytes and occasional clusters of smudged

Figure 3. Intraoperative view of the base of the aneurysmal bone cyst formed by the cranium in a cockatiel.

nuclei but no evidence of infectious microorganisms or inflammatory or neoplastic cells.

Radiographic examination included ventrodorsal and lateral views of the whole body and ventrodorsal and anterior–posterior views of the right wing. The only abnormality found on radiographs was a severely osteolytic and mildly osteoproliferative lesion in the proximal aspect of the radius surrounded by a soft tissue mass containing mineral density (Figs. 7, 8). This was initially interpreted as an aggressive neoplasm. Primary differential diagnoses for this lesion were neoplasms of subcutaneous, muscle, or bone tissue. However, infectious etiologies, especially those of bacterial or fungal origin, and noninfectious processes such as a bone cyst or abnormal callus formation were included in the differential diagnoses.

In preparation for surgical biopsy, the animal was anesthetized with isoflurane in oxygen administered by face mask. Three 5-mm incisional biopsies were collected from the ventral aspect of the mass by sharp excision and submitted for histopathologic examination. Grossly, the mass was firm, relatively immobile, and varied in color from red to tan. Postoperatively, a figure-of-eight bandage was applied to the right wing to cover the surgical site, and enrofloxacin (Baytril, 11.3 mg/ml suspension, compounded from tablets by Louisiana State University Pharmacy, Bayer Corp., Shawnee Mission, Kansas 66201, USA; 15 mg/kg, p.o., b.i.d. for 10 days) was administered. Histopathologic examination of the submitted tissue indicated no evidence of neoplasia, but extensive connective tissue was evident with foci of new bone formation. Histopathologic interpretation suggested callus formation or other causes of nonneoplastic bone production, such as a bone cyst.

Based on these histopathologic findings, the mass was surgically removed from the medial aspect of the right wing. The bird was admitted for surgery, and anesthesia was induced and maintained as previously described. A ventral skin incision revealed a thin (2 mm) osseous shell surrounding the mass. Because of the extensive nature of the lesion, partial resection of the affected tissue was performed. The mass contained a serosanguineous fluid, which was collected intraoperatively by aspiration and submitted for aerobic microbial culture. Anesthetic recovery was uneventful. Butorphanol (Torbugesic, butorphanol tartrate, 10 mg/ml,

Figure 4. Postoperative view of a cockatiel after excision of an aneurysmal bone cyst of the cranium.

Fort Dodge Animal Health, Fort Dodge, Iowa 50501, USA; 2 mg/kg, i.m.) was administered once postoperatively for analgesia, and enrofloxacin administration was continued at the same dosage regimen for an additional 10 days. A figure-of-eight bandage was placed over the surgical site, and the animal was discharged 1 day postoperatively. One week later, the cockatoo was readmitted for surgery to remove the remaining bony mass from the dorsal aspect of the wing. Anesthesia, surgical techniques, and intraoperative findings were similar to the previous surgery. The surgical approach was modified to access to the dorsal aspect of the wing. Grossly, the mass appeared as a 3-cm-diameter ovoid shell, surrounding soft friable tissue.

Postoperative radiographs included ventrodorsal and anterior–posterior views of the affected wing (Figs. 9, 10). A 3.0- × 4.0- × 1.0-cm soft tissue mass containing multiple radiolucent areas consistent with gas density was now visible distal and dorsal to the cubital joint. Although the entire proximal radial diaphysis and metaphysis were absent, the remaining proximal radial diaphysis was sclerotic with permeative osteolysis and mild periosteal proliferation. The substantially demineralized radial head was faintly radiographically apparent. Radiographic interpretation attributed radial absence as well as gas within the tissues to surgical intervention, although bacterial, fungal, or neoplastic etiologies could not be ruled out. Radiographic findings suggested the presence of a primary bone tumor such as osteosarcoma, chondrosarcoma, or fibrosarcoma, and wing amputation was recommended. Differential diagnoses considered for the abnormal radial findings included disuse demineralization, devitalized bone or sequestration due to surgical intervention, or traumatic, infectious, or neoplastic processes.

Based on the radiographic findings, the animal was returned to surgery, and the proximal remaining 4.0 cm of the radius was resected and submitted for histopathologic examination. Grossly, the resectus had a 6.0-mm, firm red mass at the proximal end. Butorphanol (1.5 mg/kg, i.m.) was administered once for pain control postoperatively, and a figure-of-eight bandage was placed to immobilize the wing. Microbial culture of the serosanguineous fluid obtained in the initial surgery produced a pure culture of small numbers of *Corynebacterium renale*, resistant to fluoroquinolones but sensitive to sulfonamides. Based on microbial culture and antimicrobial sensitivity testing, oral antibiotic admin-

Figure 5. Ventrodorsal radiographic view of the affected distal left metacarpus of an adult cockatiel with an aneurysmal bone cyst.

istration was changed to trimethoprim sulfamethoxazole (Sulfatrim Pediatric Suspension, sulfamethoxazole and trimethoprim oral suspension 200/40 mg per 5 ml; Alpharma USPD Inc., Baltimore, Maryland 21244, USA; 100 mg/kg, p.o., b.i.d.).

Histopathologic examination of the radial fragment revealed granulation tissue with cartilage and bone production. Foci of bone lysis and hemorrhage were present along with periosteal proliferation in the cortex adjacent to the proximal radial mass. The lesion was consistent with a posttraumatic callus. The second mass was sectioned so that the ''shell'' and central tissue could be assessed separately. Histopathologically, the outer wall of the mass was composed of immature fibrous bone trabeculae with intense osteoclastic activity, whereas the central tissue was composed of fibrin and packed erythrocytes. Collectively, this was interpreted as a cyst, which likely occurred as a result of bone marrow hemorrhage and hematoma formation with substantial bone remodeling. No evidence of neoplasia was found in any examined tissue, and the final morphologic diagnosis was aneurysmal bone cyst.

The bird had gained weight 7 days postoperatively and had a good appetite and normal eliminations. The bandage was intact and without swelling of the wing or apparent discomfort. The bandage was removed, and antibiotic use was discontinued 2 wk postoperatively. The owner was instructed to perform passive range of motion exercises on the wing to restore function and to release carpal contracture. Approximately 2 mo after the second postoperative examination, the animal returned for the unrelated complaint of hemorrhage from a developing feather. At this time, the owner reported no problems with the surgical site, and the wing had full return to function.

DISCUSSION

Aneurysmal bone cysts are benign, lytic, expansile lesions of bone consisting of anastomosing cavernous spaces filled with unclotted blood, fibrous tissue and, usually, osseous components.[2] These cysts are named for the distended contour of the affected bone cortices seen radiographically.[11] The definitive pathogenesis of these lesions remains unclear, but histopathologic descriptions support the

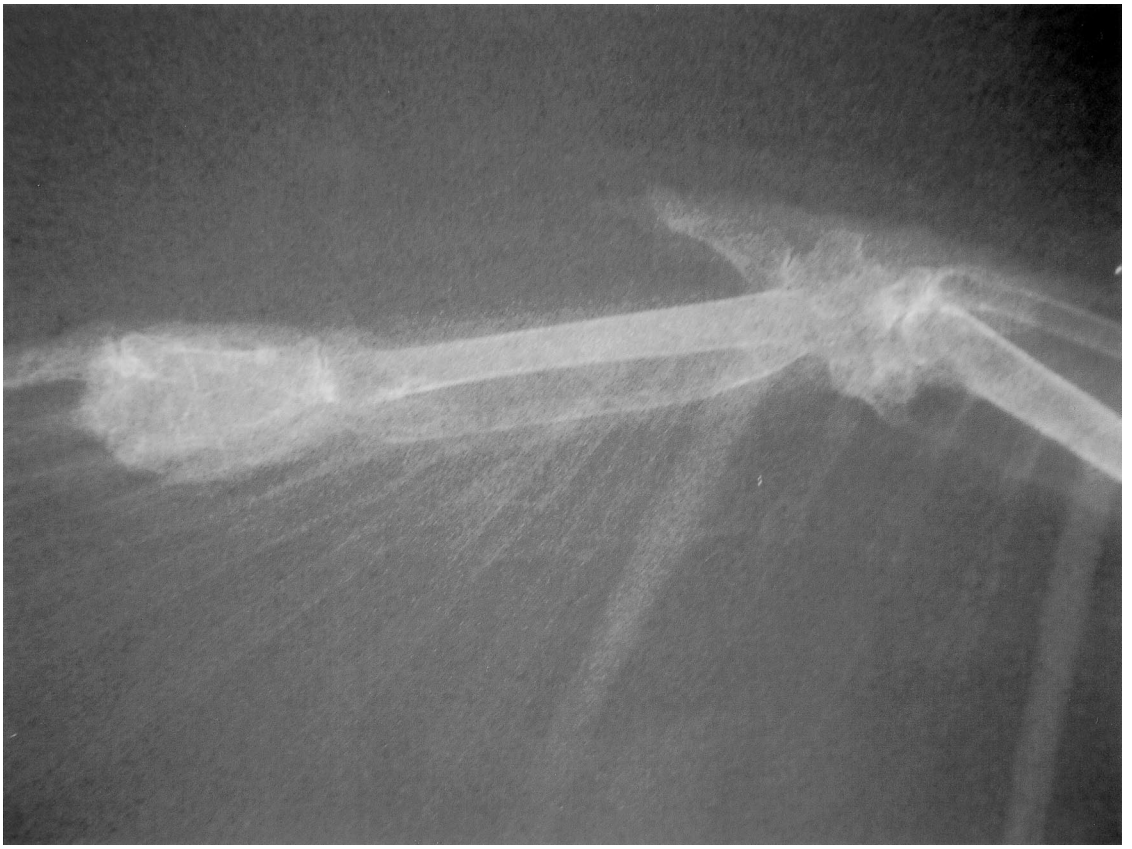

Figure 6. Ventrodorsal radiographic view of the affected distal right metacarpus of an adult cockatiel with an aneurysmal bone cyst.

concept that aneurysmal bone cysts may result when trauma or tumor induces an anomalous vascular process of the bone marrow.[11] The hemodynamic force of this marrow vascular abnormality creates a progressively expanding and thinning cortex of bone filled with blood. Thus, aneurysmal bone cysts appear to be a manifestation of a pathophysiologic change rather than the result of a single etiologic entity. Aneurysmal bone cysts have been extensively described in humans but are rarely reported in domestic animals.[3–5,11,15]

The majority of aneurysmal bone cysts in humans occur as primary lesions in which a preexisting cause cannot be identified and are termed primary aneurysmal bone cysts.[14] However, approximately 30% of human bone cysts reported are associated with a preexisting bone lesion and are termed secondary aneurysmal bone cysts.[11,14] Documented precursor lesions in humans most commonly include giant cell tumor, followed by fibrous or osseous neoplasia, eosinophilic granuloma, radiation osteitis, trauma (fracture), or metastatic carcinoma.[11] In domestic animals, osteosarcoma has been associated with aneurysmal bone cyst,[7] whereas trauma has been postulated as a causative factor in other cases.[15]

In studies of human cases of aneurysmal bone cysts, the incidence is low (0.00014%), with young adult females most commonly affected.[11,13,14] In domestic animals, rare reports document aneurysmal bone cyst, in both sexes and in both mature and immature animals.[5,15,16,21] In humans, aneurysmal bone cysts most often affect the long bones, spine, and pelvic bones.[11] In humans and animals, the metaphyseal regions of bone are most often affected.[5] In these psittacine cases, two of the birds were female, and all were >2 yr of age. Areas prone to trauma, such as the superior cranium, distal wing tips, and the anconeal joint, appeared to be a common factor in these avian cases.

Most human cases of primary aneurysmal bone cyst have pain with or without swelling and symptom duration of <6 mo.[11] In domestic animals, progressively enlarging, noninflamed masses of 2-wk

Figure 7. Ventrodorsal radiographic view of the affected left wing of an umbrella cockatoo with an aneurysmal bone cyst.

to 5-mo duration with or without lameness or pain on palpation have been reported.[3,4,7,15,18,20] Pathologic bone fracture secondary to an aneurysmal bone cyst is not uncommon in humans and occurs in domestic animals. These cases may present with acute lameness or, in cases where vertebrae are affected, have neurologic dysfunction.[11,16,18,19] Abnormal clinical signs in these case reports were limited to nonpainful, nonfluctuant, noninflamed, and rapidly growing masses on the affected areas.

Definitive diagnosis of aneurysmal bone cyst is dependent on appropriate radiographic lesions and biopsy.[5] Accordingly, differential diagnoses extend primarily from radiographic and pathologic findings. Patient age and lesion location should also influence the consideration of differential diagnoses.[19] Differentials for these osteolytic lesions should include infectious, neoplastic, inflammatory, traumatic, and dysplastic processes. Neoplastic differentials can be subdivided into primary bone tumors and secondary neoplastic processes affecting bone. Primary bone tumors for consideration include osteosarcoma, osteoma, fibrosarcoma, chondrosarcoma, osteoblastic or giant cell tumor, hemangioma, and hemangiosarcoma.[3,7,12,15–19,21] Secondary neoplastic processes affecting bone for consideration as differentials include solitary plasma cell myeloma or multiple myeloma and lymphosarcoma.[7,19] Dysplastic differentials include unicameral bone cysts and fibrous dysplasia.[12,15,16,18,20,21] Although histopathologic examination was performed in all cases reported here, no primary neoplastic lesion was identified.

Although CBC, plasma biochemistries, and cytologic findings supported the diagnosis of aneurysmal bone cyst in these cases, clinicopathologic findings could not rule out inflammatory processes including neoplastic and infectious etiologies. In the cockatoo, elevated alkaline phosphatase levels were supportive of bone activity or damage.[8] Low numbers of *C. renale* in the first surgical resectus of this case could have indicated infection or merely contamination. Although this organism is considered autochthonous flora in avian species and

Figure 8. Lateral radiographic view of the affected left wing of an umbrella cockatoo with an aneurysmal bone cyst.

none of *Corynebacterium* spp. isolated from birds have been found to be pathogenic,[10] antimicrobial sensitivity testing and corresponding antibacterial therapy, were instituted. Microbiologic sampling, antimicrobial sensitivity testing, and antimicrobial administration are indicated in aneurysmal bone cyst cases because the serosanguineous fluid often contained in these cysts provides an excellent medium for bacterial growth. Although antimicrobial testing was not performed in the cockatiels because of client constraints, antimicrobial therapy was empirically instituted.

In human cases of secondary aneurysmal bone cyst, most lesions have the radiographic appearance typical of the causative condition.[11] In cases of primary aneurysmal bone cyst, radiographic evaluation will demonstrate an eccentric, lytic lesion with an expansive remodeled or ballooned cortical contour of bone resulting from bone production of the periosteum. The lesions tend to be eccentric in long bones but may appear more centrally located or fill the entirety of shorter bones. Although cyst margins may be sclerotic and well defined, flocculent densities or faint mineralization may also be radiographically evident within the lesion. Although radiographic findings in all three psittacine cases were consistent with aneurysmal bone cyst, diagnosis was hindered in the cockatoo, where radiographic findings suggested an aggressive neoplastic process. However, radiographic findings in the second cockatiel were interpreted as consistent with the tentative diagnosis of bone cyst, likely due to previous radiologic experience with similar lesions. Although clinicopathologic and radiographic findings may be supportive of aneurysmal bone cyst, the rarity of aneurysmal bone cysts in domestic an-

Figure 9. Ventrodorsal radiographic view of the affected left wing of an umbrella cockatoo after aneurysmal bone cyst resection and partial radial resection.

imals and humans precludes definitive diagnosis without histopathologic evaluation of affected tissues.

Histologically, the aneurysmal bone cyst is defined as ''an expanding osteolytic lesion consisting of blood filled spaces of variable size that are separated by connective tissue septa containing trabeculae of bone or osteoid tissue and osteoclast giant cells.''[13] Histopathologic diagnosis is obtained more readily when material from the sinus portion is included in the biopsy.[5] An open biopsy technique is preferred to obtain sufficient sample for diagnosis and reduce the risk of damage to adjacent neural and vascular structures.[5] The cockatoo case report illustrates that multiple histopathologic evaluations of the mass may be necessary to obtain the diagnosis of aneurysmal bone cyst. The cockatiel case reports demonstrate that in some birds, size may limit the possible number of biopsies or other diagnostics possible. Complete excisional biopsy may be the primary diagnostic procedure indicated when bone cyst is suspected in the smaller (<100 g of body weight) avian cases. Surgical resection of the mass in toto is the most practical diagnostic and treatment option in these cases.

In the case of secondary aneurysmal bone cyst, the causative agent, usually a neoplasia, must be treated appropriately.[11] In the case of a primary aneurysmal bone cyst, treatment options are based on techniques to reduce blood supply to the lesion. Historic treatments include complete surgical excision, curettage with or without subsequent bone graft, radiotherapy, cryotherapy, phenol, or packing with polymethylmethacrylate, or, more recently, embolotherapy.[5,7,11,17] Although effective in treatment of aneurysmal bone cysts, radiation therapy is contraindicated because of risk of delayed secondary sarcoma.[17] In primary lesions, curettage and bone grafts are performed first with surgical removal or other more involved treatments reserved for recurrent lesions, or lesions that are nonresectable.[11] In domestic animal cases of primary aneurysmal bone cyst, only complete surgical excision or surgical curettage and cancellous bone grafting have achieved successful outcomes.[4,7]

Most domestic animals with aneurysmal bone cyst are euthanized because of a poor prognosis associated with appendage dysfunction, neurologic dysfunction, suspicion of neoplasia, or likelihood of lesion recurrence.[3,5,7,16,18,19,21] In contrast, most cases

Figure 10. Anterior–posterior radiographic view of the affected left wing of an umbrella cockatoo after aneurysmal bone cyst resection and partial radial resection.

of primary aneurysmal bone cyst in humans carry a good prognosis although recurrence is possible.[11,17] These are the first documented cases of psittacine aneurysmal bone cysts. Surgical resection of the cysts and associated bone resulted in positive outcomes, with minimal postsurgical complications.

Postoperative complications were likely related to bandage application and the inherent motion and likelihood of trauma to these areas. Specific complications were limited to swelling, birds' trauma to the bandage, carpal contracture in a cockatiel and the cockatoo, and hematoma formation in the same cockatiel. In all three cases, further radiographic evaluation was indicated to rule out further bone cyst formation. Additional clinicopathologic analysis is also recommended in these cases, dependent on bird size, to assess resolution of abnormal findings. Additional diagnostics for the cases described in this report were declined. Positive outcome of the described cases may have contributed to poor client compliance for recommended continuing reexaminations.

Acknowledgment: We acknowledge the permission of Harrison's Bird Diets International Inc. for use of Figure 1, which was originally published in Avian Medicine: Principles and Application.

LITERATURE CITED

1. Altman, R., S. Clubb, G. Dorrestein, and K. Quesenberry. 1997. Table 2: Plasma biochemical reference ranges of common psittacine species. *In*: Altman, R., S. Clubb, G. Dorrestein, and K. Quesenberry (eds.). Avian Medicine & Surgery. W. B. Saunders Co., Philadelphia, Pennsylvania. Pp. 1006–1007.

2. Baxter, G. 1996. Subchondral cystic lesions in horses. *In:* McIlwraith, C. W. (ed.). Joint Disease. W. B. Saunders Co., Philadelphia, Pennsylvania. Pp. 384–397.

3. Belknap, E., S. Brodie, J. Lowry, and R. Getzelmen. 1992. Aneurysmal bone cyst in a holstein bull. J. Am. Vet. Med. Assoc. 201: 1413–1415.

4. Biller, D., G. Johnson, S. Birchard, and R. Fingland. 1987. Aneurysmal bone cyst in a rib of a cat. J. Am. Vet. Med. Assoc. 190: 1195.

5. Bowles, M. H., and K. Freeman. 1986. Aneurysmal bone cyst in the ischia and pubes of a dog: a case report and literature review. J. Am. Anim. Hosp. Assoc. 23: 423–427.

6. Carpenter, J., T. Mashima, and D. Rupiper. 2001. Appendix 11. Hematologic and serum biochemical values for selected psittacines. *In:* Carpenter, J., T. Mashima, and D. Rupiper (eds.). Exotic Animal Formulary, 2nd ed. W. B. Saunders Co., Philadelphia, Pennsylvania. Pp. 195–200.

7. Duval, J., J. Chambers, and S. Newell. 1995. Surgical treatment of an aneurysmal bone cyst in a dog. Vet. Comp. Orthop. Traumatol. 8: 213–217.

8. Fudge, A. 2000a. Avian liver and gastrointestinal testing. *In:* Fudge, A. (ed.). Laboratory Medicine of Avian and Exotic Pets. W. B. Saunders Co., Philadelphia, Pennsylvania. Pp. 47–55.

9. Fudge, A. 2000b. Chapter 46. Laboratory reference ranges for selected avian, mammalian and reptilian species. *In:* Fudge, A. (ed.). Laboratory Medicine of Avian and Exotic Pets. W. B. Saunders Co., Philadelphia, Pennsylvania. Pp. 375–400.

10. Gerlach, H. 1994. Bacteria. *In:* Ritchie, B., G. J. Harrison, and L. R. Harrison (eds.). Avian Medicine: Principles and Application. Wingers Publishing, Inc., Lake Worth, Florida. Pp. 949–983.

11. Kransdorf, M., and D. Sweet. 1995. Aneurysmal bone cyst. Am. J. Roentgenol. 164: 573–580.

12. Lamb, C., and S. Schelling. 1989. Congenital aneurysmal bone cyst in the mandible of a foal. Equine Vet. J. 21: 130–132.

13. Leithner, A., R. Windhager, S. Lang, O. Hass, F. Kainberger, and R. Kotz. 1999. Aneurysmal bone cyst—a population based epidemiologic study and literature review. Clin. Orthop. Relat. Res. 363: 176–179.

14. Martinez, V., and H. Sissons. 1988. Aneurysmal bone cyst—a review of 123 cases including primary lesions and those secondary to other pathology. Cancer 61: 676–683.

15. Momiyama, N., M. Tagami, N. Tsunoda, and H. Taniyama. 1999. Aneurysmal bone cyst in a colt. Equine Vet. Educ. 11: 243–246.

16. Pernell, R., R. Dunstan, and C. Camp. 1992. Aneurysmal bone cyst in a six-month-old dog. J. Am. Vet. Med. Assoc. 201: 1897–1899.

17. Randall, R., S. Nork, and P. James. 2000. Aggressive aneurysmal bone cyst of the proximal humerus: a case report. Clin. Orthop. Relat. Res. 370: 212–218.

18. Renegar, W., L. Thornberg, R. Burk, and S. Still. 1979. Aneurysmal bone cyst in the dog: a case report. J. Am. Anim. Hosp. Assoc. 167: 933–934.

19. Shiroma, J., S. Wiesbrode, D. Biller, and M. Olmstead. 1993. Pathological fracture of an aneurysmal bone cyst in a lumbar vertebra of a dog. J. Am. Anim. Hosp. Assoc. 29: 434–437.

20. Steiner, J., and V. Redano. 1982. Aneurysmal bone cyst of the horse. Cornell Vet. 72: 57–63.

21. Walker, M., J. Duncan, J. Shaw, and W. Chapman. 1975. Aneurysmal bone cyst in a cat. J. Am. Vet. Med. Assoc. 167: 933–934.

Received for publication 19 May 2003