Use of magnetic resonance imaging and histopathologic findings for diagnosis of an aneurysmal bone cyst in the scapula of a cat

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Case Description—An 18-month-old spayed female domestic shorthair cat was evaluated because of left thoracic limb lameness.

Clinical Findings—A firm mass was palpable in the left scapular region. On the basis of clinical signs; results of radiographic, ultrasonographic, and cytologic evaluations; and findings on magnetic resonance imaging, an aneurysmal bone cyst (ABC) of the scapula was strongly suspected.

Treatment and Outcome—Considering the large size of the mass and the poor prognosis for return to function of the left thoracic limb, amputation was elected. Histologic evaluation ruled out a malignant process and was diagnostic for ABC originating from the left scapula. The patient recovered well and was ambulatory the day after surgery. Three years after surgery, the cat was healthy.

Clinical Relevance—The combination of radiography, regional ultrasonography, and magnetic resonance imaging enabled lesion structure and cavity content evaluation. However, final diagnosis was confirmed by histologic evaluation. To our knowledge, this is the first veterinary report of the use of magnetic resonance imaging in the characterization and diagnosis of an ABC. (J Am Vet Med Assoc 2012;240:69–74)

An 18-month-old spayed female domestic shorthair cat was evaluated at the Companion Animal Hospital of the University of Montreal because of left thoracic limb lameness and a firm mass slowly growing for several months over the left shoulder area. The cat’s previous medical history was unremarkable with no history of trauma.

At the time of evaluation, the cat was bright, alert, and responsive. Orthopedic examination revealed a firm but fluctuant mass approximately 10 cm in diameter over the left scapular region. Palpation in this area elicited signs of pain, and the cat had moderate left thoracic limb lameness. Distal to the mass, the rest of the limb appeared normal. Neurologic examination and the remainder of the physical examination revealed no other abnormalities.

After clipping of hair and aseptic preparation of the skin, fine-needle aspiration of the mass was performed and the fluid was submitted for cytologic evaluation. The results were consistent with a blood-containing cavity. The blood that came out of the needle was not clotted.

Hematologic and serum biochemical analyses were performed. A CBC revealed a mild regenerative anemia, with a PCV of 24% (reference range, 24% to 45%) and a reticulocyte count of 440,020 \( \times 10^9 \) reticulocytes/L. Neutrophilic leukocytosis was noted with a WBC count of 24.8 \( \times 10^9 \) WBCs/L (reference range, 5.55 \( \times 10^9 \) WBCs/L to 19.5 \( \times 10^9 \) WBCs/L) and a neutrophil count of 20.3 \( \times 10^9 \) neutrophils/L (reference range, 2.5 \( \times 10^9 \) neutrophils/L to 12.5 \( \times 10^9 \) neutrophils/L). Mild hypoalbuminemia (27.80 g/L; reference range, 29 to 39 g/L) and hypoglobulinemia (25.10 g/L; reference range, 29 to 47 g/L) were noted. Serum alkaline phosphatase activity was high (128 U/L; reference level, < 50 U/L).

All the other serum biochemical and hematologic variables were within reference limits.

Radiographs of the left shoulder joint were provided by the referring veterinarian, including 1 mediolateral view and 2 caudocranial views. The left scapula was no longer identifiable with marked septated (ie, soap bubble appearance) multilocular expansile lysis completely replacing the normal bone. Because of the expansile nature, the bone changes occupied approximately twice the size of the normal scapula. The humeral head seemed to be preserved. Moderate swelling of the soft tissues surrounding this bone lesion was noted. Distal to the shoulder joint, the limb appeared normal. The portion of the thorax included on the radiographs also appeared normal.

To evaluate the architecture of the mass and find a more accurate location for fine-needle aspiration, ultrasonography of the left scapular region was performed by use of a 5- to 8-MHz microconvex transducer. The

**ABBREVIATIONS**

<table>
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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>ABC</td>
<td>Aneurysmal bone cyst</td>
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<tr>
<td>FLAIR</td>
<td>Fluid-attenuated inversion recovery</td>
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<tr>
<td>MRA</td>
<td>Magnetic resonance angiography</td>
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<td>MRI</td>
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10^9 WBCs/L to 19.5 \( \times 10^9 \) WBCs/L and a neutrophil count of 20.3 \( \times 10^9 \) neutrophils/L (reference range, 2.5 \( \times 10^9 \) neutrophils/L to 12.5 \( \times 10^9 \) neutrophils/L).

Magnetic resonance imaging (MRA) and fluid-attenuated inversion recovery (FLAIR) sequences were performed. MRA revealed an expansile multilocular lesion with a thin mural rim. FLAIR images were used to identify the fluid collection. Fluid and aspirate were submitted for cytologic evaluation. Cytologic examination revealed no evidence of malignancy.

Magnetic resonance angiography (MRA) was performed to evaluate the blood supply to the mass. MRA revealed a hyperintense signal on the arterial phase consistent with an aneurysmal bone cyst.

The patient recovered well and was ambulatory the day after surgery. Three years after surgery, the cat was healthy.

**Clinical Relevance**—The combination of radiography, regional ultrasonography, and magnetic resonance imaging enabled lesion structure and cavity content evaluation. However, final diagnosis was confirmed by histologic evaluation. To our knowledge, this is the first veterinary report of the use of magnetic resonance imaging in the characterization and diagnosis of an ABC. (J Am Vet Med Assoc 2012;240:69–74)
mass contained multiple cavitary zones filled with a moderately echogenic fluid containing slow-moving particles, likely representing blood. In most of these cavities, this fluid had a slow swirling pattern. A pulsatile color Doppler ultrasonographic signal was visible in some areas and was interpreted as blood ejection into the cavitations. Throughout the mass, there were irregular echogenic interfaces with acoustic shadowing, consistent with the remaining underlying lytic bone. The mass was directly adjacent to the cranial portion of the thoracic wall. The conclusion of the ultrasonographic examination was a vascular mass either originating from the scapula or enveloping it (Figure 1).

To allow further characterization of the mass and surgical planning, MRI and contrast-enhanced MRA were performed by use of a 1.5-T superconducting magnet; the cat underwent general anesthesia and was placed in ventral recumbency. In addition to pre- and postcontrast T1-weighted, T2-weighted, FLAIR, and steady-state gradient echo images, contrast-enhanced MRA images were made at the time of contrast agent injection and approximately every 40 seconds thereafter for 4 minutes. Magnetic resonance angiography images were obtained by use of a 3-D spoiled-gradient time-of-flight acquisition. As with the radiographic and ultrasonographic examinations, the normal scapula could not be identified, being completely replaced by the multiloculated mass (11 × 10 × 8 cm). A large (5.5-cm-diameter), irregularly and thinly margined central cavity was noted as well as multiple other smaller cavities of various diameters. The cavities were filled with fluid and associated sediment. The fluid was hyperintense on T2-weighted and FLAIR images and hypointense on T1-weighted images, indicating a proteinaceous content. Conversely, the sediment was hypointense on T2-weighted images, less hypointense with FLAIR images, and hyperintense with T1-weighted images, compatible with sedimented sanguinous fluid. Particularly on the medial and dorsal aspects of the mass, the walls of the cavities had a signal void consistent with compact bone and fibrous tissue. After contrast medium administration, the mass and cavity walls had immediate intense enhancement (Figures 2 and 3). Although it was difficult to illustrate with a single image, a slow progressive enhancement was also noted of the fluid within these cavities and appeared as a swirling pattern of 2 signal intensities. Contrast-enhanced MRA permitted 3-D reformatting of the mass and delineation of the major regional vascular structures, including the left subclavian and axillary arteries and left subclavian and brachial veins (Figure 4). No major vascular

Figure 1.—Dorsal color flow Doppler ultrasonographic image of a mass in the left scapular region of an 18-month-old spayed female cat evaluated because of left thoracic limb lameness and a firm mass that had been growing for several months. The mass contains multiple cavitary zones filled with a moderately echogenic fluid. The pulsatile color Doppler ultrasonographic signal is interpreted as blood ejection into the cavitations. Cr = Cranial.

Figure 2.—Transverse MRI images of the thorax at the level of the scapular region of the same cat as in Figure 1. Notice the multiloculated mass (11 × 10 × 8 cm) replacing the left scapula. On the T1-weighted image (A), the fluid (asterisk) is hypointense and the sediment is hyperintense. Note the horizontal fluid-fluid level (white arrow). After contrast medium administration (B), the mass and cavity walls had immediate intense enhancement. Scale indicates centimeters. L = Left.
structure was seen to enter the mass. Although the left axillary artery seemed to penetrate the mass on a single image, comparison of multiple views lead to the conclusion that it was in fact displaced by the mass. The mass displaced the pectoral muscles ventrally. The subscapularis, serratus dorsalis, trapezius, and rhomboid muscles were displaced dorsally. The serratus ventralis and the scalenus muscles were displaced medially. The mass was immediately adjacent to the intercostal muscles and ribs of the cranial portion of the thoracic wall but did not appear to invade the surrounding tissue. The mass was consistent with a lytic, highly vascular primary osseous lesion involving the entire left scapula. Because of the slow flow and lack of involvement of a major vessel, an arteriovenous fistula was considered less likely, although it was impossible to rule out.

Considering the signalment, history, clinical signs, and combined imaging features, a benign osseous vascular lesion, such as an ABC, was strongly suspected. Although less likely, telangiectatic osteosarcoma, hemangioma, or hemangiosarcoma was also part of the differential diagnosis, and histologic examination was considered necessary to confirm the diagnosis.

Because of the size of the mass and the poor prognosis for return to function of the limb, amputation was elected. Prior to surgery, a paravertebral nerve block (at the level of C5 through C7) was performed with lidocaine (1.5 mg/kg [0.68 mg/lb]) and bupivacaine (1 mg/kg [0.45 mg/lb]) while the cat continued to be under general anesthesia. A thoracic limb amputation including the scapula was performed. For immediate postoperative pain control, hydromorphone (0.05 mg/kg [0.023 mg/lb], IV, q 4 h) for 24 hours and a constant rate infusion of medetomidine (1 µg/kg/h) for 12 hours were administered. No complications occurred during the procedure or the postoperative period. The cat recovered well from surgery and was discharged 2 days after the procedure. Tolfenamic acid (4 mg/kg [1.82 mg/lb], PO, q 24 h) was prescribed for 3 days.

The entire limb and the left prescapular lymph node were submitted for histologic examination. The scapula was diffusely and massively enlarged, up to $15 \times 10 \times 10$ cm, particularly on the medial aspect. On the cut surface, the mass contained multiple cystic structures and contained approximately 125 mL of serosanguineous fluid. Microscopically, the cysts contained numerous sinusoidal spaces up to 1 cm in diameter separated by septa that occasionally surrounded and replaced the skeletal muscle of the scapula. The septa reached up to a thickness of 1 cm and were composed of

Figure 3—Dorsal T2-weighted MRI image at the level of the vertebral column of the same cat as in Figure 1. Notice that the mass has multiple cavities containing hyperintense fluid (asterisk). Notice the normal left humeral head (arrow) and the right scapula (arrowheads). Scale indicates centimeters. L = Left.

Figure 4—Contrast-enhanced MRA 3-D reformatted image of the left dorsal aspect of the mass of the same cat as in Figure 1. Notice that major vessels are displaced by the mass. BCT = Brachiocephalic trunk. Cr = Cranial. L AxA = Left axillary artery. L SCA = Left subclavian artery. R SCA = Right subclavian artery. Inset illustrates image orientation.
unnumbered haphazardly arranged cords and bundles of spindle to polygonal cells with moderate to abundant amounts of extracellular collagenous stroma of variable cellularity or osteoid. The cells lining the osteoid were often polygonal. Moderate numbers of multinucleate giant cells were present adjacent to the sinusoids and the trabeculae of osteoid. The sinusoids were often lined by attenuated spindle to polygonal cells and contained large numbers of erythrocytes and smaller numbers of macrophages, often with brown granular pigment within their cytoplasm (hemosiderin). Occasional lymphocytes and plasma cells were present adjacent to the sinusoids (Figure 5). The maturity of the collagenous stroma and the histologic appearance of the adjacent spindle cells, with polygonal cells lining the osteoid, were not consistent with a bone neoplasm in a veterinary patient; however, the lesion from a telangiectatic osteosarcoma, which was interpreted as blood ejection into the cavitations. These findings were helpful to rule out most of the differential diagnoses. However, it was impossible to distinguish the lesion from a telangiectatic osteosarcoma, which shares this blood-filled cavitary appearance with ABC.

For the cat of the present report, ultrasonographic findings were consistent with a cavity mass most likely containing swirling blood. The pulsatile color Doppler ultrasonographic signal that was seen was interpreted as blood ejection into the cavitations. These findings were helpful to rule out most of the differential diagnoses. However, it was impossible to distinguish the lesion from a telangiectatic osteosarcoma, which shares this blood-filled cavitary appearance with ABC.

Magnetic resonance imaging was extremely useful to further investigate the structure of the mass and its relationship with surrounding tissues as well as to plan for surgical resection. To the best of our knowledge, this is the first report involving the use of MRI for the diagnosis of an ABC in a veterinary patient; however, ABC has often been described by use of this imaging modality in humans. Magnetic resonance imaging signals found on ABC in humans have a low signal intensity on T1-weighted images and high intensity on T2-weighted images, compatible with fluid. Similar to the cat in the present report, when the patient is motionless for several minutes, fluid-fluid levels, which are the sign of sedimentation in the dependent aspect of the cavities, are often found in humans with ABCs. However, this finding is not specific for ABC because sedimentation has been described in tumor-associated hemorrhage and blood-filled intramedullary cavities. A hypointense circular rim around the entire lesion can be seen and is consistent with the presence of a fibrous capsule. Finally, the strong enhancement seen after in-
projection of gadolinium is a sign of the highly vascular nature of ABCs. This intense postcontrast enhancement was also seen in the cat of the present report. However, the progressive enhancement that was noted within the fluid itself and that appeared as a swirling pattern seems to be a new finding unreported in human medicine. These MRI findings may represent slow hemorrhage or vascular communication within a cystic cavity. Nonetheless, these signs are not specific for ABC because other bone lesions can have the same features. Magnetic resonance angiography permitted delineation of the regional vascular structures and therefore allowed for more accurate surgical planning. In veterinary medicine, MRA is usually used for the investigation of vascular abnormalities such as thrombosis, portosystemic shunts, and arteriovenous fistula.

To our knowledge, the present report is the first in veterinary medicine on the use of MRA to further characterize an ABC.

Although some clinical signs and diagnostic imaging methods may help clinicians in characterizing the problem, the rarity of ABCs in veterinary medicine makes histologic examination mandatory to rule out another bone disease and obtain a definitive diagnosis. Grossly, ABC is a sponge-like lesion that seems to originate from cancellous bone and expands against the overlying cortex. Microscopically, it is composed of variable-size blood-filled cavities, separated by trabeculae of fibrous-osseous tissue. Solid islands of this same osseous tissue are dispersed throughout the lesion. The irregular bone septa are lined by osteoblasts, and the cavities contain erythrocytes, hemosiderophages, and osteoclast-like giant cells. The blood contained in the cavities is not clotted. Abundant periosteal bone formation is also found around the lesion. Aneurysmal bone cyst is not histologically a true cyst because it does not have an epithelial lining. Furthermore, it is not an aneurysm either, but it is so called because of its radiographic appearance. One of the major histologic differential diagnoses is a highly aggressive telangiectatic osteosarcoma. In the cat of the present report, the extracellular collagenous matrix had gradual maturation, and the cells lining the osteoid generally had a distinct polygonal morphology, which differed from the more spindle cell morphology of the surrounding cells. These findings were not consistent with an osteosarcoma.

Since it was first introduced by Jaffe and Lichtenstein in 1942, the characterization of ABC has always been descriptive. Although various mechanisms have been proposed by some authors to explain the development of such lesions, the exact physiopathology of ABC is still unknown. In fact, the term ABC is only based on a lesion description and does not imply any concept of etiology. Aneurysmal bone cyst is often described as a rare benign expansile osteolytic lesion involving the bones of humans and, less commonly, of animals. In the veterinary literature, it has been reported in horses, dogs, cattle, 

Bone destruction associated with ABC appears to be due to a disturbance in the normal bone vasculature. An increase in circulatory venous pressure would be responsible for the formation of blood-filled cavities eroding the parent bone. Venous thrombosis, arteriovenous fistula, and subperiosteal hematoma formation have been described as potential precursor events for the development of ABCs. However, it is still unclear whether this change in vasculature occurs de novo or is the result of a preexisting neoplastic, traumatic, or dysplastic bone lesion. Some reports failed to find any precursor lesion, whereas others described ABC as a potential consequence of another bone disease. Therefore, ABC has been divided by some investigators into a primary and a secondary form. The most frequent primary lesions that are reported in affected humans include giant cell tumor, fibrous or osseous neoplasia, eosinophilic granuloma, radiation osteitis, trauma, and metastatic carcinoma. In the veterinary literature, an underlying osteosarcoma has been described, and trauma is a common feature in the patient’s history. In the cat of the present report, the history did not reveal any trauma, and histologic examination ruled out any other concomitant bone disease, which led to the diagnosis of primary ABC. However, it is important to note that a traumatic event could have been missed by the owner.

Treatment of ABC is controversial and depends on the location of the lesion. Many therapeutic options, such as curettage, bone grafting, amputation, full resection, and radiation, have been described in humans. The most recommended treatment usually consists of high-speed burr curettage with or without bone grafting or en bloc resection when feasible. Preoperative embolization has also been described to reduce intraoperative blood loss. Even with these techniques, ABC in humans is still associated with a high rate of recurrence, ranging from 10% to 50%. In dogs and cats, curettage with cancellous bone grafting, curettage with bone cement, en bloc resection, and surgical resection with vascularized cortical bone grafting have been described as successful treatments for ABC. Other cases required amputation or euthanasia. Malignant transformation of ABC into chondrosarcoma or osteosarcoma has been reported after surgical treatment in both the human and veterinary literature.

References


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b. Echo Speed HDx, General Electric Healthcare Canada, Mississauga, ON, Canada.