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

Jérôme Benamou, DVM; Bertrand Lussier, DVM, MSc, DACVS; Kate Alexander, DVM, MSc, DACVR; Malcolm J. Gains, DVM, DVSc, PhD, DACVP; Claudine Savard, DVM, MSc

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)

Abbreviations

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<th>ABC</th>
<th>Aneurysmal bone cyst</th>
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<td>FLAIR</td>
<td>Fluid-attenuated inversion recovery</td>
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<td>MRA</td>
<td>Magnetic resonance angiography</td>
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<td>MRI</td>
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An 18-month-old spayed female domestic shorthair cat was evaluated at the Companion Animal Hospital of the University of Montréal 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 X 10^9/L. Neutrophilic leukocytosis was noted with a WBC count of 24.8 X 10^9/L (reference range, 5.5 X 10^9/L to 19.5 X 10^9/L) and a neutrophil count of 20.3 X 10^9 neutrophils/L (reference range, 2.5 X 10^9 neutrophils/L to 12.5 X 10^9 neutrophils/L). Mild hypoaalbuminemia (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...
The 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 X 10 X 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...
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 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, hemangiomia, 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 $15\times10\times10$ 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](image1.png)

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](image2.png)

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.
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Discussion
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ate giant cells were present adjacent to the sinusoids
amounts of extracellular collagenous stroma of variable
spindle to polygonal cells with moderate to abundant
numerous haphazardly arranged cords and bundles of
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noccellarity or osteoid. The cells lining the osteoid were
often polygonal. Moderate numbers of multinucleat
ge giant cells were present adjacent to the sinusoids
and the trabeculae of osteoid. The sinusoids were of
ten 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). Occa
sional lymphocytes and plasma cells were present ad
jacent 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
forming cysts containing blood (ie, telangiectatic osteo
sarcoma) but were indicative of an ABC. The lymph
node was slightly enlarged and contained numerous
lymphoid follicles extending into the medulla. It was
considered to be reactive and histologically normal.

With complete excision, the prognosis was consid
ted to be excellent for survival. Three years after surgery,
the owner was contacted and reported that the cat was in
excellent condition, actively running and jumping.

Discussion
Patients with ABCs usually have a history of slow
growing painful swelling, progressive lameness, or any
other signs that may be related with the lesion’s location
(eg, tenesmus, dysuria, and neurologic signs). Signs of
pain are a common clinical sign and have been as
associated with bone destruction and compression of the
surrounding soft tissues. Even if it rarely invades a joint,
ABC is often seen at the end of a long bone, thus caus
ing joint pain and gait alteration. In the patient of the
present report, the cyst was growing for several months,
and there were signs of pain on palpation. Therefore, the
lameness observed during orthopedic examination could
have been due to pain, could have been mechanical be-
cause of the proximity with the shoulder joint, or could
have resulted from a combination of both.

Hematologic values are usually within the reference
range in patients with ABC, except for a high serum al
kaline phosphatase or creatinine kinase activity. In
the cat of the present report, serum alkaline phosphatase
activity was high, which could have been associated with
osteolytic changes. Mild regenerative anemia was also
noted and was interpreted as the result of chronic blood
loss into the multiple cavities of the cyst.

Radiographically, ABC is an expansile osteolytic le
sion that has often been described as resembling a soap
bubble because of its septated appearance. The lesion of
ten seems to arise from the medullary cavity and expands
in a centrifugal fashion, therefore causing a bulging and
thinning of the overlying cortex. It tends to be eccen
tric in long bones, but it can be more centrally located,
especially in flat or short bones. Its locally destructive
behavior makes it difficult to distinguish from a malign
ant neoplastic process. As a consequence of bone de
struction, pathologic fractures may be associated with
ABCs. The cat of the present report had almost all
the radiographic features usually described for ABCs.
For instance, the expansile nature of this lesion was ob
vious because the scapula was almost doubled in size.

The differential diagnosis for this type of lesion in
cludes inflammatory, infectious, traumatic, neoplastic,
and dysplastic processes. Neoplastic etiologies should
be divided into primary bone tumors, such as osteosarcoma,
hamangioma, hemangiosarcoma, chondrosarcoma, fibrosar
oma, or giant cell tumor; and secondary bone tumors,
such as multiple myeloma or lymphoma. Dysplastic causes
include fibrous dysplasia or unicameral bone cysts.

For the cat of the present report, ultrasonograph
ic findings were consistent with a cavitory mass most
likely containing swirling blood. The pulsatile color
Doppler ultrasonographic signal that was seen was in
terpreted 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 in
tensity 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 mo
tionless 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-

Figure 5—Photomicrograph of a section of the wall lining one of
the cystic spaces of the mass from the same cat as in Figure 1.
Notice the erythrocytes in the lumen (L), multinucleate giant cells
adjacent to the lumen, osteoid lined by angular polygonal cells
(arrow), and mature collagenous stroma subjacent to the cyst (ar
rowhead). Hematoxylin, phloxine, and saffron stain; bar = 50 µm.
jection 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 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 Jaife 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 veterinary literature, it has been reported in horses, cattle, donkeys, camels, dogs, cats, a llama, and psittacines. Although it has been more frequently described in the metaphyseal region of long bones, occurrence on a rib, pelvis, scapula, vertebra, or mandible has been reported. In humans, ABC is more common in the first 20 years of age and seems to affect slightly more females than males. However, its incidence in animals cannot be classified in terms of age, sex, or breed predisposition.

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 and. 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 59%. 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