Imaging of primary bone tumors in veterinary medicine: which differences?

Poster No.: C-1514
Congress: ECR 2011
Type: Educational Exhibit
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Keywords: Bones, Digital radiography, CT, MR
DOI: 10.1594/ecr2011/C-1514

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Learning objectives

Animals remain a model in research in several domains. However, in spite of the biological similarities, bone tumors in veterinary medicine are most often an unknown and mysterious world for the human doctors.

Background

Primary bone tumor is always considered a differential diagnosis for lameness or neurological signs in veterinary medicine especially for small animals but has been reported in most of the animal species.

As animals cannot talk, they are not able to say when they feel pain in their leg or their back. Therefore, the bone tumor is generally extensive when the animal is presented to the veterinarian and associated with obvious clinical signs the owner was able to observe.

Bone tumors are mostly the same that the one encountered in human and share common imaging features. Radiographs remains the main imaging modality used in veterinary medicine for bone tumor evaluation.

But as the treatments are different (a leg amputation does not affect the quality of life for most of the dogs or cats), the needs for imaging differ.

Imaging findings OR Procedure details

BENIGN TUMORS

Benign primary bone tumors (osteoma (Fig 1 on page 7), osteochondroma (Fig 2 on page 7), multiple cartilaginous exostoses, angioma (Fig 3), giant cell tumor (Fig 4 on page 9), cyst (Fig 5), chondroma...) are not common in veterinary medicine. They can be underdiagnosed because they are generally not painful and presentation is often motivated by compression of the surrounding structures. Radiographs are often sufficient to reach a diagnosis. Benign tumors appear radiographically as well limited (Lodwick I) with no soft tissue involvement nor periosteal bone formation unless there is an associated fracture tumor¹. Further imaging modalities are generally not necessary except in case of axial locations associated with neurological signs.

MALIGNANT TUMORS
Malignant primary bone tumors are much more frequently diagnosed, probably because the clinical signs are severe enough for the owner to notice them and bring his animal to the vet.

**Ewing's sarcoma**, a common malignant tumor in children, is not reported in domestic animals. The etiology of this tumor is related to the antigen CD99. This antigen is not present in animals except monkeys, which probably explains the absence of this tumor in veterinary medicine.

**Osteosarcoma** is by far the most common primary bone tumors in veterinary medicine since it represents more than 80% in dogs and 70% in cats of primary tumors originating from the skeleton.

In dogs, large to giant breeds are predisposed and especially German Shepherd, Saint Bernard, Great Dane, Irish Setter, Doberman Pinscher, Labrador and Golden Retrievers. No breed predisposition has been identified in cats or horses.

It is unclear whether there is a sex predisposition or not including the neutered status.

In dogs, age repartition for osteosarcomas is bimodal (old dogs with a median of 7 years old and young dogs between 1-2 years old). In cats, older individuals only seem to be affected (above 10 years old). Data on horses are insufficient.

The hypothesis that the distribution of osteosarcomas is related to weight bearing distribution is the same in small animals. As in men, about 75% of osteosarcomas in dogs occur in the appendicular skeleton.

Metaphyseal region of long bones are predisposed site, especially the distal radius, proximal humerus, distal femur and proximal tibia\(^2\textsuperscript{-5}\) (Fig 6 on page 11 - Fig on page 12). This explains the well-known learning sentence: "Away from the elbow, close to the stifle". The spine, the ribs and the pelvis are also affected even if less frequently \(^5\textsuperscript{-7}\) (Fig 8).

In cats, osteosarcomas seem to be more equally distributed\(^8\).

For the herbivores, as the most common localization is the skull, it has been speculated that the long period spent masticating may be a predisposing factor\(^9\textsuperscript{,}10\).
The average duration of clinical signs before consultation is classically shorter in dogs than in cats, but is generally longer than in human medicine, since the owner has to be aware of his animal's issue\textsuperscript{7,11,12}.

**Chondrosarcoma** is the second in incidence of all canine primary bone tumors, representing about 10% of primary bone tumors in dogs\textsuperscript{13-15}. Large breed dogs are mostly affected whereas no breed predilection has been found in cats\textsuperscript{15}.

In dogs, chondrosarcoma originates mainly from nasal cavity but also flat bones like ribs, scapula and pelvis\textsuperscript{13} (Fig 9 on page 14). Long bones seems to be more affected in cats\textsuperscript{15}.

**Fibrosarcoma** accounts for less than 5% of all primary bone tumors in dogs\textsuperscript{2}. In cats, fibrosarcoma are mainly of soft tissue origin, especially vaccine induced, between both scapulas\textsuperscript{8}.

They originate mainly from metaphyses of long bones, ribs and vertebrae and grow very rapidly (Fig 10).

**Angiosarcomas** are also rare in veterinary medicine and occur more commonly in dogs rather than in other species (Fig 11 on page 16).

They are locally destructive and highly metastatic to the lungs and internal organs as spleen, liver, heart, kidneys, skeletal muscles or brain\textsuperscript{2,8}.

Other bone tumors, similar to the one found in human medicine can occur in veterinary medicine but they are scarce (multiple myeloma, lymphosarcoma, liposarcoma...)

Before the bone tumor diagnosis is made, the owner has to notice an abnormality in his animal (lameness, growing mass, neurological symptoms...) and then bring him to his vet. Indeed, the animal won't manifest itself if they feel a little pain. This explains why the disease is generally at an advanced stage on presentation.

**DIAGNOSTIC IMAGING**

For the majority of primary bone tumors, radiological appearance is similar and can vary from bone lysis to osteosclerosis, and all the intermediates between these two extremes
Cortical lysis, new bone formation, sunburst effect and Codman's triangle are commonly seen features in malignant tumors.

However, chondrosarcomas produce a cartilaginous matrix, and appears on radiographs as a multilobular lesion, with often round calcifications and a radiolucent center (cartilage) classically referred as a "popcorn ball".

Main differential for bone tumors is osteomyelitis, specifically of fungal etiology. Distinction between bone tumor and bone infection will be made based on history and clinical data.

To make a definitive diagnosis, a bone biopsy is generally performed under ultrasound, fluoroscopy or CT-guidance.

In veterinary medicine, CT and MRI require a general anesthesia; or sometimes deep sedation for the CT. This increases the risk and the cost of the procedure. That's why they are used mostly for axial locations, in order to assess the anatomic delimitations of the tumor and the surrounding structures; whereas radiographs are generally sufficient for appendicular locations.

Treatment is based upon complete surgical excision and possible adjuvant therapies.

When an amputation is considered for an appendicular bone tumor, radiographs and bone biopsy are usually enough to make a diagnosis. However, limb-sparing procedures are developed and are now another surgical option for appendicular osteosarcomas in dogs. This technique is recommended if the dog presents a severe orthopedic issue affecting another limb, as severe osteoarthritis, or if he is too heavy. Also, some owners would not accept an amputation on their animal, because of social aspect. What have been mostly reported so far in veterinary medicine are limb-sparing procedures on the distal radius and ulna even if this can be performed on other bones. The main problem with this procedure is local recurrence, due to an incomplete resection of the tumor, and presence of residual neoplastic cells. Accurate delimitations of the tumor are then necessary for this type of procedure.

Several studies compared different imaging modalities (CT, MRI and bone scintigraphy) with histopathology on osteosarcoma cases, to evaluate their accuracy. For now, they do not lead to the same conclusion but this is probably due to the small number of dogs in each study. Generally, all modalities overestimated the tumor length compared with histological examination.
However, on living dogs, MRI seems to be the most accurate modality for evaluation of osteosarcomas\(^{18}\). Bone scintigraphy is on the other hand useful to detect bone metastasis\(^{18}\).

Pulmonary metastatic disease is rarely detected on radiographs at the time of diagnosis. Indeed, on dogs having an appendicular osteosarcoma, they are diagnosed on less than 10% of affected dogs even if about 90% of them have already micrometastatic disease\(^{19}\).

CT remains the more sensitive approach for lung metastasis\(^{19}\) but is not always feasible because of the cost and the need of a general anesthesia or a deep sedation.

**BIOLOGIC BEHAVIOR AND PROGNOSIS**

Biologic behavior differs a lot between animals and between tumors.

In dogs, osteosarcomas are particularly agressive, both locally and systemically since metastases are very common\(^{19}\). This is similar to biological behavior of osteosarcomas in humans\(^{4,20}\). Because of the common long time between beginning of the disease and presentation, most of the patients will die within weeks or months after diagnosis\(^{3,4,8}\). The locations for metastasis are principally lungs but also bone or soft tissue\(^{20}\) (Fig 12). Skip metastasis has also been reported\(^{21}\) (Fig 18).

Unlike dogs, osteosarcomas in cats are locally invasive but slow to metastasize, with an overall incidence of metastatic rate less than 10%\(^{5,11}\).

Even if few data are available for horses, a retrospective study suggests that the biologic behavior of equine osteosarcomas is similar to the cats\(^{9}\) (Fig 19).

Chondrosarcoma and fibrosarcoma seem to be locally invasive but less systemically aggressive than osteosarcomas in dogs and cats\(^{8,14,15}\). Contrary to osteosarcomas, metastasis is not the primary cause of treatment failure but rather local recurrence\(^{15}\).

On the contrary, angiosarcomas are locally destructive and highly metastatic to the lungs and to internal organs as spleen, liver, heart, kidneys, skeletal muscles or brain\(^{2,8}\). The survival is very poor, and amputation is usually palliative and not curative\(^{2,8,22}\).

In all types of tumor, axial locations tumors are associated with a poorer prognosis due to the difficulty of performing a complete surgical resection.
Fig. 1: Transverse CT image of an osteoma in a dog. Osseous proliferation with a very neat definition on the right maxillary bone.
**Fig. 2:** Lateral radiograph of a horse carpus. Fairly homogeneous new bone formation with irregular margins is present on the caudal aspect of the distal radius. These appearance and location are characteristic of an osteochondroma.

![Image of a horse carpus with new bone formation](image)

**Fig. 3:** Sagittal and transverse post contrast medium T1-W (a,c) and T2-W (b,d) MR images of a cat presenting with weakness and hindlimbs ataxia. An angioma causes bone lysis of T11 with extension of the tumor within the spinal canal, compressing the cord (arrow).
Fig. 4: T2-W MR image of a giant cell tumor of the atlas in a horse. Clinical findings was behavior changings, pain and hyperesthesia in the neck and severe ataxia on four limbs, worsening for 2 months. Radiographs were unremarkable. MRI was performed to assess the brain. A hyperintense and heterogenous lesion was found in the atlas medullary cavity (white arrow), which causes cortical lysis. The spinal cord was not reached and clinical signs were explained by an excruciating pain.
**Fig. 5:** Dorsal (a) and sagittal (b) T2W MR images of a scapular aneurysmal bone cyst in a cat. Sedimentation is noted in several cavities (arrowheads)
Fig. 6: Lateral radiograph of a lytic osteosarcoma of the proximal humerus in a dog.
**Fig. 7:** Lateral radiograph of an osteosclerotic osteosarcoma of the distal radius in a dog. Soft tissues are massively involved.

**Fig. 8:** Axial CT (a, b) of an osteosarcoma of the left pedicle of C6 in a dog. Purely lytic aggressive lesion.
Fig. 9: Axial CT of a chondrosarcoma of a rib in a dog. Lysis of the costo-chondral junction (white arrow) and the huge intra-thoracic (arrowheads) and parietal extension. The tumor is lobulated and hypodense without the usual round calcifications.
Fig. 10: Lateral (a) and cranio-caudal (b) views of a fibrosarcoma in a cat. Lytic lesion (black arrows) in the distal part of the scapula.
**Fig. 11:** Radiograph of an angiosarcoma in a horse, involving mostly the scapular spine. Scapula radiographs on a horse is technically difficult and only cranio-caudal projection of the lateral aspect can be obtained. However, heterogenous aspect of the bone is visible (white arrows).
Fig. 12: Lateral radiographs of a humerus osteosarcoma in a lioness. The purely lytic primary lesion is on the right thoracic limb (a - arrow) and a lytic bone metastasis is present on the left humerus (b). The lion was non-bearing on the right thoracic limb.
Fig. 13: Cranio-caudal (a and b) and lateral (c) radiographs of a falcon with an distal humerus sclerotic osteosarcoma (white arrows).
**Fig. 14:** Ventrodorsal whole-body radiograph of a rib osteosarcoma in a hedgehog. A round soft tissue opacity was observed, involving the right thoracic wall and extending laterally (arrows).
**Fig. 15:** CT scan images of a multiple myeloma in a dog. On the transversal views, lysis of the body of T8 (a). Lysis and enlargement are also present on the head of the ninth rib (b). In the sagittal plan (c), a fracture by compression is visible on T8 (black arrow) associated with a soft tissue protrusion into the vertebral canal (black arrowhead).
Fig. 16: Transverse (a) and reformatted dorsal (b) CT images of a vertebral lymphoma in a ferret, showing lysis of the left pedicle and the caudal articular process of C3.
Fig. 17: Lateral views on bone scintigraphy (a) and radiographs (b) of an osteosarcoma of the distal radius in a dog.
**Fig. 18:** Axial (a) and coronal reconstruction (b) CT of a distal tibia osteosarcoma in a dog. Agressive lytic lesion with a skip metastasis (arrow). The dog was amputated and is fine one year later.
Fig. 19: Lateral (a) and dorso-palmar 60° (b) radiographs of a distal phalanx osteosarcoma in a horse presented for a severe lameness. Lysis and remodeling of the bone (black arrow).
Conclusion

In the end, biology of primary bone tumors in human and in veterinary medicine is mostly the same. However, the approach for diagnosis and treatment is different. Indeed, advanced technology in diagnostic imaging are not as available in veterinary medicine as it is in human medicine and complementary exams like CT, bone scan or MRI are not considered as routine for animals. Plus, a general anesthesia or at least, a deep sedation is needed to perform these exams. Moreover, the stakes are not the same. Indeed, the perception of the society towards an amputation is not a problem in the animal world whereas it can be in the owner's mind. If no pathologic condition is present on the controlateral limb, amputation does not prevent dogs or cats from any activity.

Because biology of primary bone tumors in animals resembles the one of human beings, it is certainly beneficial for both to work together for a better understanding of the behavior, diagnosis and treatment of these entities in veterinary and human medicines.

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The authors thank Dr E.N.Carmel and Dr K.Alexander (Service d'imagerie, Faculté de Médecine Vétérinaire, Université de Montréal), for their assistance.

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