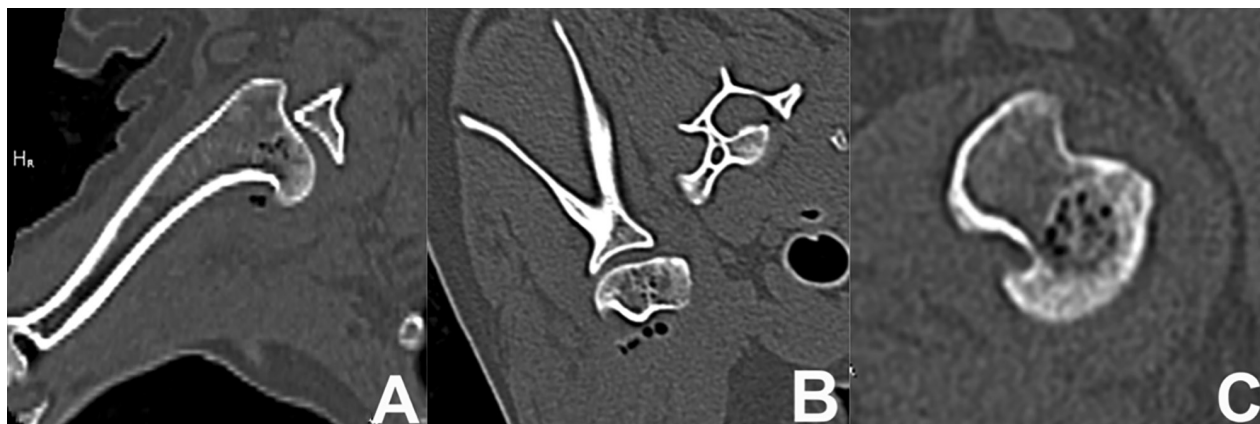




## What Is Your Diagnosis?



**Figure 1**—Sagittal (A) and dorsal (B) plane CT images of the right shoulder joint and transverse plane CT image of the right humeral head (C) of an 11-year-old 5.4-kg (11.9-lb) castrated male Maltese mixed-breed dog with a 5-day history of right forelimb lameness. Images are in 1-mm slice thickness with bone algorithm (window width, 2,500 HU; window level, 300 HU). A—Cranial is to the left of the image, and proximal is to the top of the image. B—The dog's right is to the left of the image, and dorsal is to the top of the image. C— The dog's right is to the left of the image, and cranial is to the top of the image.

### History

An 11-year-old 5.4-kg (11.9-lb) castrated male Maltese mixed-breed dog was referred for evaluation of right forelimb lameness. The owner reported an acute onset of clinical signs with a 5-day history of progressive, non-weight-bearing right forelimb lameness that coincided with anorexia that started at the same time. The referring veterinarian had localized signs of pain to the dog's right shoulder joint but detected no clinically relevant radiographic abnormalities. Hematologic evaluation performed by the referring veterinarian revealed a mild regenerative anemia and thrombocytopenia. The dog had a history of right anal sac adenocarcinoma, which was surgically removed along with a sublumbar lymph node the previous spring. In addition, the dog had been receiving chemotherapy (toceranib; dose unavailable) since the diagnosis of the anal sac adenocarcinoma, with no substantial abnormal findings on monthly hematologic evaluation until this point. Toceranib was discontinued, and the dog was referred for orthopedic evaluation.

On initial referral examination, the dog had no masses detected at the site of the previous anal sacculectomy, no neurologic abnormalities were detected, and the remainder of findings were unremarkable, except for potential enlargement of the sacral lymph nodes (detected on rectal examination) and signs of severe pain and mild intracapsular swelling localized to the right shoulder joint. With the right scapula stabilized by applying medial pressure over the acromion, signs of pain were most severe when the right forelimb was extended or abducted.

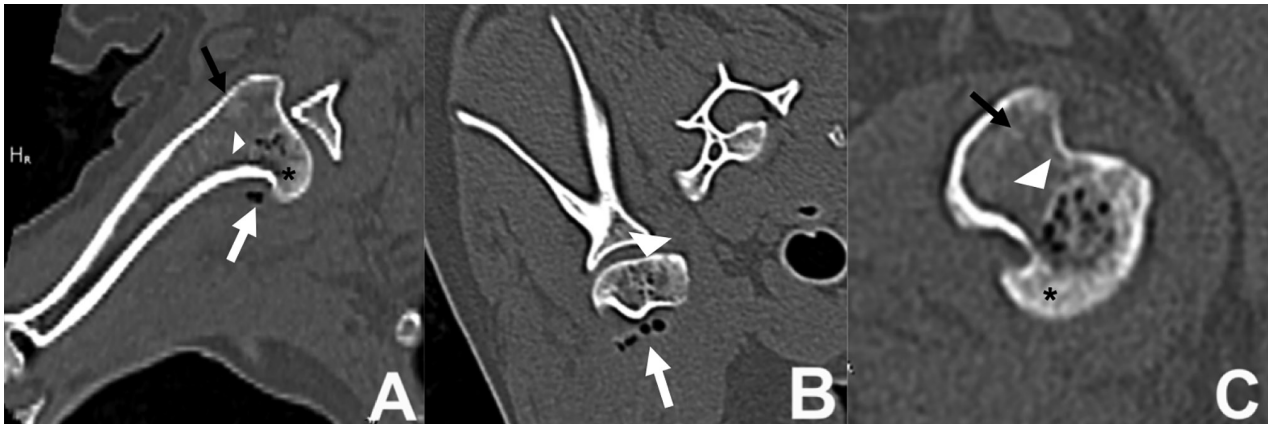
Results of a CBC indicated a normocytic, normochromic anemia (Hct, 33.5% [reference range, 37.0% to 55.0%]; mean corpuscular hemoglobin concentration, 32.9 g/dL [reference range, 32.0 g/dL to 36.0 g/dL]); a moderate leukocytosis ( $23.92 \times 10^3$  WBCs/ $\mu$ L; reference range,  $6.0 \times 10^3$  WBCs/ $\mu$ L to  $17.0 \times 10^3$  WBCs/ $\mu$ L), characterized by neutrophilia ( $18.42 \times 10^3$  neutrophils/ $\mu$ L; reference range,  $3.0 \times 10^3$  neutrophils/ $\mu$ L to  $11.4 \times 10^3$  neutrophils/ $\mu$ L) with a left shift (band neutrophil count, 0.9568 band neutrophils/ $\mu$ L; reference range, 0.0 to 0.3 band neutrophils/ $\mu$ L) and few toxic neutrophils; mild monocytosis ( $3.35 \times 10^3$  monocytes/ $\mu$ L; reference range,  $0.15 \times 10^3$  monocytes/ $\mu$ L to  $1.35 \times 10^3$  monocytes/ $\mu$ L); and mild thrombocytopenia ( $104 \times 10^3$  platelets/ $\mu$ L; reference range,  $200 \times 10^3$  platelets/ $\mu$ L to  $500 \times 10^3$  platelets/ $\mu$ L). The dog's prothrombin time (9.2 seconds; reference range, 5.5 to 7.9 seconds) and activated partial thromboplastin time (20.0 seconds; reference range, 10.4 to 19.3 seconds) were slightly high. Results of serum biochemical analyses were unremarkable.

Without administration of contrast medium, CT of the dog's brachium and shoulder joint region bilaterally was performed (representative images from the right forelimb are shown; **Figure 1**).

**Determine whether additional imaging studies are required, or make your diagnosis from Figure 1—then turn the page →**

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**Figure 2**—Same images as in Figure 1. There is gas attenuation in the intra-articular space of the right shoulder joint (white arrows; A and B) and in the medullary cavity of the proximal aspect of the right humerus (arrowheads; A through C). The caudal aspect of the humeral head is sclerotic (asterisks; A and C), and there are patches of sclerosis in the medullary cavity of the greater tubercle (black arrows; A and C).

## Diagnostic Imaging Findings and Interpretation

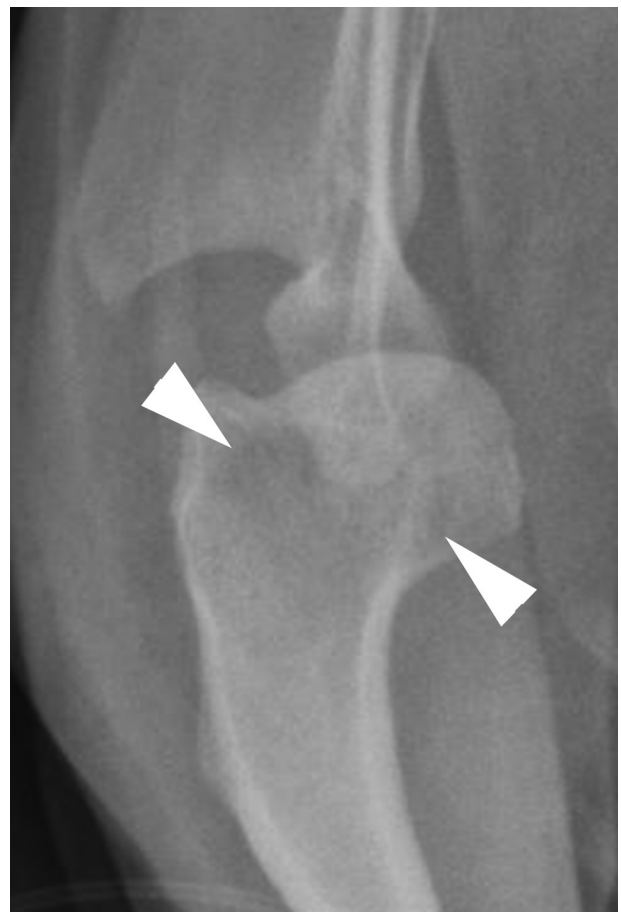
Findings on CT included gas-attenuating foci in the right caudomedial aspect of the shoulder joint and centrally in the medullary cavity of the right humeral head (**Figure 2**). Attenuation of the proximal aspect of the medullary cavity of the right humerus was mildly decreased (approx 148 HU; range, -82 to 210 HU), compared with that of the contralateral humerus (approx 347 HU; range, 157 to 391 HU; not shown). The right prescapular lymph node was mildly to moderately enlarged; however, there was no evidence of cortical lysis or periosteal new bone formation. The remaining soft tissue structures of the right brachium were clinically normal without evidence of soft tissue masses, fluid pockets, or hemorrhage.

Radiographic examination was performed, and results interpreted retrospectively with CT findings included a faint, round area of radiolucency in the region of the right humeral head distal to the subchondral bone and an area of even more subtle radiolucency in the greater tubercle of the humerus in the caudocranial radiographic view of the right shoulder joint (**Figure 3**).

Overall results of physical, CT, and radiographic examinations supported a differential diagnosis of intraosseous pneumatosis of the proximal aspect of the right humerus and intra-articular emphysema likely associated with septic osteomyelitis of the right humeral head. Less likely differential diagnoses included neoplasia and trauma.

## Treatment and Outcome

Arthrocentesis was performed on the affected joint, and results of cytologic evaluation of the sample obtained indicated marked suppurative inflammation with moderate numbers of degenerative neutrophils and no definitively neoplastic cells. Arthroscopy was



**Figure 3**—Caudocranial radiographic view of the right shoulder joint of the dog in Figures 1 and 2. There are 2 areas of poorly defined radiolucency (arrowheads) in the greater tubercle and medial aspect of the humeral head.

then performed on the affected joint and revealed diffuse, severe synovitis, fibrinous exudate, and erosion of the articular cartilage (grade<sup>1</sup> II [surface fibrillation] to III [deep fissuring]). The exudative material was re-

moved, and the joint was copiously lavaged with lactated Ringer solution. Samples obtained from the shoulder joint were submitted for histologic evaluation and bacterial culture and susceptibility testing.

Results of histologic evaluation indicated severe, subacute, fibrinosuppurative and granulating inflammation. Results of culture and susceptibility testing yielded a monoclonal growth of *Clostridium perfringens* susceptible to clindamycin, enrofloxacin, and ampicillin. Antimicrobial treatment with clindamycin phosphate (13.9 mg/kg [6.3 mg/lb], IV, q 12 h), enrofloxacin (10.0 mg/kg [4.5 mg/lb], IV, q 24 h), and ampicillin-sulbactam (30.0 mg/kg [13.6 mg/lb], IV, q 8 h) was initiated, as was pain management with fentanyl (1.0 to 5.0 mg/kg/h [0.5 to 2.3 mg/lb/h], IV, constant rate infusion), lidocaine hydrochloride (2.0 mg/kg/h [0.9 mg/lb/h], IV, constant rate infusion), and gabapentin (50.0 mg/kg [22.7 mg/lb], PO, q 8 h). Three days after arthroscopy, the dog had improved in that it was weight-bearing but mildly lame on its right forelimb, showed no other signs of discomfort, and had a clinically normal appetite. The dog was discharged with prescriptions of clindamycin hydrochloride (13.9 mg/kg, PO, q 12 h), enrofloxacin (13.6 mg/kg [6.2 mg/lb], PO, q 24 h), and ampicillin-sulbactam (13.9 mg/kg, PO, q 12 h) for 30 days, along with continued administration of gabapentin (50 mg/kg, PO, q 8 h for 10 days) and placement of a fentanyl patch (25 µg/h, transdermal) that was to be removed in 3 days.

## Comments

Intraosseous pneumatosis is an uncommon finding in veterinary medicine. It has been reported most commonly in human medicine after biopsy, penetrating wounds, or fracture.<sup>2</sup> Although intraosseous pneumatosis has rarely been reported in conjunction with osteomyelitis in humans,<sup>3</sup> there is a much higher predisposition for it in conjunction with osteomyelitis in the extra-axial skeleton versus the axial skeleton, especially in patients with diabetes mellitus or neoplasia.<sup>4</sup> Other causes of intraosseous pneumatosis include degenerative disease, osteonecrosis, and neoplasia.<sup>4</sup> In addition, CT evidence of gas in joint spaces can be caused by a vacuum phenomenon, which has been associated with osteochondrosis of the shoulder joint<sup>5</sup> and intervertebral disk disease<sup>6</sup> in dogs. This vacuum phenomenon would not result in attenuation within the subchondral bone on CT images as seen in the dog of the present report, unless there was concurrent bony erosion or fracture of the subchondral bone, neither of which was present in the dog.

The proposed mechanism of action resulting in intraosseous pneumatosis secondary to osteomyelitis

is bacterial anaerobic metabolism that produces hydrogen and carbon dioxide gases.<sup>3</sup> Because *C perfringens* was isolated from the affected shoulder joint of the dog in the present report but the dog had no evidence of a penetrating wound or other trauma, we suspected that immunosuppression from chemotherapy may have been an underlying predisposing factor.

Typical abnormal radiographic findings in patients with osteomyelitis can lag approximately 1 week after the onset of infection and include soft tissue swelling, periosteal thickening, cortical destruction, sequestra, and periosteal reaction.<sup>7</sup> Alternatively, CT may reveal bony abnormalities earlier in the course of disease progression than radiograph, and typical CT findings in patients with osteomyelitis include increased medullary density, sclerosis, demineralization, periosteal reaction, and sequestra.<sup>7</sup> In the dog of the present report, results of CT were much more obvious than results of radiography and better helped drive the treatment choices made. Without CT evidence of intraosseous pneumatosis in the dog of the present report, other differential diagnoses (eg, neoplasia) for the subtle bony lysis identified on radiography would have been prioritized. No contrast medium was administered to the dog in the present report because of procedures anticipated to be performed after CT; however, the use of contrast medium could have been helpful to better assess soft tissues, such as the joint capsule. Veterinarians should be aware that intraosseous gas unrelated to biopsy, fracture, or trauma could be associated with underlying osteomyelitis in small animals and that CT may yield more obvious abnormal findings earlier in the disease progression than might radiography.

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