Panosteitis is an idiopathic, painful bone disease of young and growing dogs. Speculated causes include oversupplementation of calcium and other minerals; viral, bacterial, or other infectious causes; and genetic predispositions. German shepherds are most commonly affected by panosteitis, and Great Dane puppies with high calcium intake, specifically during the preweaning period, can develop radiographic signs of the disease. Also, some evidence suggests that protein or amino acid metabolism is affected in dogs with panosteitis, but it has not been determined whether this condition is a cause or an effect of panosteitis.

The pain noted on palpation of the affected bone is a result of inflammation of the periosteum. Increased fibroblastic and osteoblastic activity creates congestion in the marrow, endosteum, and periosteum. Pain is the result of increased pressure from the medulla, periosteum, or both. As the inflammation resolves, secondary deposition of woven bone leads to some of the changes seen on radiographs. In most cases, the disease is mild and self-limiting. Rare cases can be severe, and despite intensive, supportive care, morbidity and mortality can be high in severe cases.

**DIAGNOSTIC CRITERIA**

**Historical Information**

**Gender Predisposition**
- Males may be at increased risk (~70%).
- The first episode in females is frequently associated with the first estrus.

**Age Predisposition**
- The disease is most prevalent in dogs that are 6 to 18 months of age, but the age range reported in the literature is 2 months to 5 years.

**Breed Predisposition**
- Odds ratio >1.2, listed in order of highest (5.3) to lowest risk: Great Pyrenees, mastiffs, basset hounds, Chinese Shar Peis, giant schnauzers, German shepherds, Bernese mountain dogs, English springer spaniels, Saint Bernards, Dalmatians, Great Danes, Irish wolfhounds, American Staffordshire terriers, Neapolitan mastiffs, Rhodesian ridgebacks, Afghan hounds, bulldogs, Doberman pinschers, English setters, Newfoundland, Weimaraners, Akitas, boxers, Chesapeake Bay retrievers, chow chows, West Highland white terriers, bull terriers, German shorthaired pointers, Labrador retrievers, golden retrievers, Rottweilers, Shih Tzus, American cocker spaniels.

**Owner Observations**
- Shifting-leg lameness unrelated to exercise.
- Recurrent pain and reluctance to move, which can vary from mild to moderate; severe cases are infrequent.
- Lethargy and inappetence.

**Other Historical Considerations/Predispositions**
- Previous episodes of lameness.

**Physical Examination Findings**
- Pain on digital palpation of the diaphyses of the long bones.
- Fever may be present or absent.

**Laboratory Findings**
- Laboratory findings are usually unremarkable.
- An inflammatory or stress leukogram may be present.

**Other Diagnostic Findings**

**Radiography**
- Confirmatory radiographic changes include:
  - **Early stages**: Increased opacity of the medullary canal; patchy lesions that are most common around the nutrient foramen.
  - **Progression** is usually indicated by a mottled appearance of varying radiographic densities in the medullary canal, elevation and thickening of the periosteum, thickening of the bone cortices, or increased intramedullary bone density.
  - **Resolution** is indicated by resolving sclerotic lesions over several months.
- Radiographic changes lag behind the disease’s progression by days to a few weeks.
  - No visible changes may be seen in diaphyseal regions of pain at the time of clinical presentation.
  - Radiographic changes often remain apparent after resolution of the localized inflammation.
  - If the history includes previous episodes of lameness, a radiographic examination of the previously affected limbs may identify changes consistent with panosteitis without revealing changes at a current site of localized pain.
Nuclear Scintigraphy

- Bone scintigraphy is an extremely sensitive tool for detecting panosteitis and other forms of skeletal pathology. It is especially useful when lameness cannot be precisely localized and in the early stages of panosteitis before radiographic changes become apparent.
- Lesions can be identified by increased radiopharmaceutical uptake ($^{99}$m technetium methylene diphosphonate); however, these tests are usually available only at specialty practices and universities.

Summary of Diagnostic Criteria

- Shifting-leg lameness.
- Pain on digital palpation of the diaphysis.
- Varying radiographic density surrounding the medullary canal initially around the nutrient foramen.

Diagnostic Differentials

- Most dogs with panosteitis present with mild to moderate severity. The orthopedic examination is straightforward, with pain present on palpation of the diaphysis.
- In some cases, the orthopedic examination can be less definitive because of the patient’s disposition (e.g., stoic, fractious). In cases in which musculoskeletal pain is present but its location is not clear, joint disease may be a differential.
- The following diagnostic differentials usually present with unique signs in addition to musculoskeletal pain and fever, and these cases need not be considered as differentials for the pain and fever seen in patients with moderate to severe panosteitis. However, the following list discusses some differentials that can occasionally present in a manner similar to panosteitis.

Infectious Diseases

- Toxoplasmosis, neosporosis (other concurrent signs may involve the central nervous, ocular, respiratory, gastrointestinal, and cardiac systems).
  — Signs include pain localized to the muscles and fever.
  — Laboratory findings include an inflammatory leukogram; eosinophilia; and increased levels of serum alanine aminotransferase, aspartate aminotransferase, and (in some cases) alkaline phosphatase.
  — Diagnosis is made by demonstration of a serum IgM titer above 1:64 on enzyme-linked immunosorbent assay (ELISA) or indirect fluorescent antibody test or ELISA.
- Hepatozoonosis:
  — The patient’s history usually includes some travel to the southern United States or outside of the United States.
  — Signs include fever and pain localized to the muscles.
  — Laboratory findings include normocytic, normochromic anemia; severe leukocytosis; occasional thrombocytopenia; hyperglobulinemia; hypoalbuminemia; and increased serum creatine kinase.
  — Diagnosis is made by muscle biopsy (Hepatozoon americanum), demonstration of gamonts in blood smear (Hepatozoon canis), and indirect fluorescent antibody tests or ELISA.
  — Polymerase chain reaction on whole blood.

Epiphysitis or Osteomyelitis

- This condition usually results from bacteremia that localizes near the end arterial loops of the metaphysis of the long bones, and it can invade the joints.
- Signs include pain localizable or generalized on the orthopedic examination, an inflammatory leukogram, and fever.
- Radiographic signs supportive of this diagnosis include periosteal reaction and lysis.
- Blood and urine cultures may identify the organism to aid appropriate treatment.
- The patient often has a history of surgery or a penetrating wound at the site of osteomyelitis.

Septic Mono- or Polyarthritis

- Septic polyarthritis is usually seen at 1 to 6 weeks of age. Infectious monoarthropathy is more commonly seen in older puppies.
- Arthrocentesis with greater than 40,000 neutrophils/µl with or without bacteria confirms diagnosis but does not separate infectious from immune-mediated arthritis.
- Synovial fluid may have a turbid or purulent appearance. Synovial fluid and tissue cultures may identify the organism but may yield negative cultures, even in the presence of infection.
- Bacteria phagocytized by neutrophils (required to make the diagnosis) is uncommon, even in infectious cases, and false-negative culture results are found 50% of the time. Bacteria destroy cartilage quickly, so response to treatment with antibiotics (while waiting for test results) is a good diagnostic tool.

Polyostotic Bone Cysts

- This condition may be associated with fibrous dysplasia, can cause pain and lameness, and can be visualized on radiographs.
Osteopetrosis (Rare)
- Osteopetrosis a failure of calcified cartilage resorption during growth, resulting in heavily mineralized bones.
- The condition is heritable in Australian shepherds and dachshunds.

TREATMENT RECOMMENDATIONS

Initial Treatment
Nonsteroidal antiinflammatory drugs (NSAIDs): Different NSAIDs or corticosteroids should not be given concurrently. The following may be used during painful episodes (the list is not all-inclusive): $•
- Carprofen: 2.2 mg/kg PO bid.
- Deracoxib: 1–2 mg/kg PO sid.
- Meloxicam: 0.1 mg/kg PO sid.
- Firocoxib: 5 mg/kg PO sid.
- Tepoxalin: 10 mg/kg PO sid.

Alternative/Optional Treatments/Therapy
- Acupuncture may be an adjunctive form of therapy for patients with severe disease to help control pain and inflammation. Trigger points are directed at the muscles associated with the areas of pain and inflammation. Limited data are available on acupuncture’s efficacy. $–$$
- Some consider corticosteroids to be an alternative to NSAID therapy. Concurrent steroid and NSAID therapy is contraindicated because of the increased risk of gastrointestinal perforation. If used, the dose should be limited to an antiinflammatory dose such as prednisone 0.5–1.0 mg/kg sid during painful episodes. $

Supportive Treatment
- Hospitalization: The majority of cases are mild and do not require hospitalization; however, hospitalization should be considered for moderately compromised cases and is necessary in severe cases. The cost of hospitalization varies depending on its duration. $–$$
- Fluid therapy should be provided as needed depending on the patient’s hydration status. $
- Gastroprotectants may be beneficial during NSAID or corticosteroid administration.
  - Sucralfate: 1 g/30 kg body weight q6–8h PO. $
  - Omeprazole: 0.5–1.0 mg/kg/day PO. $
  - Famotidine: 0.5–1.0 mg/kg q12–24h PO. $
  - Ranitidine: 0.5–2.0 mg/kg q8–12h PO. $

- Nutritional support:
  - Use of an antiinflammatory diet rich in omega-3 fatty acids should be considered to decrease available arachidonic acid for use in the inflammatory cascade. $
  - For moderate to severe cases, feeding tubes (nasoesophageal, esophageal, gastrostomy) should be considered for patients unwilling to eat at least resting caloric requirements [(Body weight × 30) + 70]. $–$$
- Soft bedding with frequent rotations (every 4 to 6 hours) should be provided to decrease the risk of decubital ulcers if the patient remains recumbent.

Patient Monitoring
- Adequate nutritional intake and hydration status should be ensured.

Home Management
- Weight reduction should be attempted because, as with all orthopedic diseases, obesity increases the forces through bones and joints, contributing to discomfort.

Milestones/Recovery Time Frames
- Repeated episodes may occur, although recurrence in the same bone is uncommon.
- The radiographic course of the disease in each site lasts about 90 days. Clinical signs typically last only a few days.
- Most dogs recover fully by 18 to 20 months of age. Numerous cases (11%) occur in dogs older than 2 years of age, according to the Veterinary Medical Database.

Treatment Contraindications
- Patients with hypovolemia should be rehydrated before NSAID administration.
- Renal function should be monitored carefully during NSAID administration in patients with underlying renal disease.

PROGNOSIS

Favorable Criteria
- Mild to moderate signs that respond well to treatment.

Unfavorable Criteria
- Severe signs that do not respond to treatment (rare). Additional diagnostics for concurrent disease or an alternate differential diagnosis should be considered in these patients.

RECOMMENDED READING
See the Recommended Reading list on p. 12.


