Lower Limb Linear Bone Scintigraphy Activity: A Case-Based Illustrative Review

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Case Presentation
An 18-year-old lacrosse player presented with persistent bilateral lower extremity pain, for which nuclear medicine scintigraphy was performed (Figure 1).

FIGURE 1. Tc-99m hydroxydiphosphonate (HDP) delayed anterior-posterior (AP, upper) and lateral (lower) planar images of the legs demonstrate linear patchy uptake involving the bilateral tibial posterior cortices. Perfusion and blood pool phase images (not shown) were normal.
Key Imaging Finding
Lower limb linear long bone activity

Differential Diagnoses
- Medial tibial stress syndrome (shin splints)
- Fracture
- Osteomyelitis

Discussion
Lower extremity pain is a common complaint across age groups. In many situations, the clinical picture may be suggestive, but is often not definitive for a specific diagnosis. Radiographs are often the first study of choice but may be normal or equivocal. Bone scintigraphy has long been a popular and accessible next imaging option of choice and may provide useful information as to the etiology of lower extremity pain, impacting patient treatment and management options. Common conditions demonstrating a linear pattern of lower limb long bone activity include medial tibial stress syndrome (MTS), fractures, and osteomyelitis, detailed below. Other uncommon etiologies, such as venous stasis and hypertrophic pulmonary osteoarthropathy, are not discussed in this case review.

Medial Tibial Stress Syndrome
Medial tibial stress syndrome (MTS), colloquially known as shin splints, results from repetitive stress injury to the leg. The clinical presentation is exertional leg pain localized along the posterior medial border of the middle and/or distal thirds of the tibias. Radiographs are typically normal (Figure 2). Tc-99m bone scintigraphy has long been a useful tool in confirming this syndrome and excluding more severe pathologic mimics. Abnormal delayed phase uptake is typically seen in most, but not all, proven cases of MTS. Abnormal delayed phase uptake is typically seen in most, but not all, proven cases of MTS. Perfusion and blood pool phases are typically normal.

Three patterns of uptake are closely associated with MTS: superficial uptake along the anterior and posterior tibial cortices (double stripe sign), localized middle to distal tibial posteromedial
cortex activity (Figure 1),\(^3\) and tubular pattern of tibial activity.\(^4\) MTS most commonly involves at least one-third of the tibial shaft, is usually bilateral, and is often asymmetric and heterogenous.

Histological changes of MTS include osteocyte loss, enlarged lacunae, disrupted lamellar structure, and periosteal thinning or thickening. Interestingly, the extent and severity of histologic periosteal changes do not correlate with the intensity of uptake. This disparity has been suggested to represent differences between early and late reparative phases of the disease process with abnormal activity preceding significant histologic changes.\(^1\)

MRI can provide a useful adjunct assessment in equivocal cases with a progressive spectrum of findings, including normal or linear increased fluid signal periosteal edema with or without increased fluid signal marrow (Figure 3). The presence of intracortical abnormal signal crosses into the imaging patterns of occult stress fracture. In this clinical setting, the extent and severity of MRI findings has been shown to correlate with the likelihood of response to conservative treatment and time to return to sports activity.\(^5\)

Fracture

Traumatic and stress fractures present with a fusiform or linear appearance (Figure 4). Stress fractures more commonly are transversely oriented to the cortex but longitudinal or oblique orientations may occur in about 10%.\(^6\) Combination of hyperperfusion, hyperemia, and delayed activity is typical, and in a young healthy patient appears within 24 hours of the inciting event. Delayed images at 72 hours may provide increased sensitivity, especially for elderly patients who may have delayed reparative response. Overall sensitivity of radionuclide imaging approaches 100%.\(^6\) The pattern and severity of the fracture will determine the need for surgical vs. nonsurgical reduction and immobilization to facilitate healing. Uncomplicated fracture activity will persist for at least 6 months with most resolved by 2 years, excluding chronic nonaligned injuries, which may have indefinitely prolonged activity.\(^7\)

Osteomyelitis

Infection shares the hyperperfusion, hyperemic, and intense delayed phase activity that is seen in fractures and can be focal, fusiform, linear, or diffuse in distribution (Figure 5). The scintigraphic appearance has a high accuracy (> 90%) in the setting of high clinical index of suspicion, but a low specificity if the clinical presentation is equivocal.\(^7\) Additional studies, such as radiographs, MRI, indium-111-labeled autologous-leukocytes, or biopsy may be required for diagnostic confirmation. The high negative predictive value of a normal bone scintigraphy represents its best utility. Treatment
may include antibiotics and/or surgical debridement. Untreated or chronic osteomyelitis may result in progressive bone destruction, abscess formation, and sepsis with significant increase in mortality.

**Diagnosis**
Medial tibial stress syndrome (shin splints)

**Summary**
Bone scintigraphy is a useful and commonly utilized tool for assessing lower extremity pain. While the patterns of linear uptake among the differential diagnoses may overlap to some degree, subtle differences may be apparent, which when combined with the clinical picture, provide clues to the underlying diagnosis. Correlation with additional imaging – often radiographs – is helpful in suggesting the most likely diagnosis. Often, the best practical application of bone scintigraphy is when it is normal, providing a high degree of confidence in excluding each of these processes. The radiologist should have a general understanding of bone scintigraphy’s role in the workup of a patient with lower extremity pain, be familiar with the common pathologic entities and their presenting patterns on scintigraphy, and be cognizant of the impact of imaging findings in terms of patient management and outcomes.

**Figures**

*FIGURE 5.* A 61-year-old woman with worsening left leg pain and a lateral leg skin ulcer. Tc-99m HDP delayed planar images over the distal lower legs (A) demonstrate linear marked increased uptake along the distal fibular shaft (arrows). There is also slightly greater overall soft-tissue activity and a larger appearance of the left leg compared to right, consistent with hyperemia and swelling. Frontal radiograph of the left ankle (B) shows subtle periosteal reaction along the lateral distal fibula (arrows) subjacent to a large cutaneous defect from an overlying skin ulcer (*). There is diffuse soft-tissue edema.

**References**