Detection of Hypervascular Brown Tumors on Three-Phase Bone Scan

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A patient with hyperparathyroidism secondary to chronic renal failure had multiple bony lesions with increased activity on both immediate static as well as delayed scintiphotos. One lesion in the distal femur was also exceptionally hot on the flow phase. Plain radiographs demonstrated lytic lesions with sclerotic margins and a narrow zone of transition. Open biopsy revealed histology consistent with brown tumor (osteoclastoma).

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CASE REPORT

A 20-yr-old female with a left pelvic renal transplant underwent three-phase ^{99m}Tc-MDP bone scanning following recent detection of several new lytic bone lesions in the left acetabulum and right femoral neck (Fig. 1). She had undergone renal transplantation at age 11 yr, secondary to renal failure from involvement of her kidneys and liver with arteriovenous malformations. She subsequently developed avascular necrosis (AVN) of the left hip secondary to chronic steroid usage. The patient was experiencing both chronic rejection of her renal transplant and hyperparathyroidism with a serum calcium of 9.2 mg/dl (normal 8.5–10.9) and elevated parathyroid hormone (PTH) level of 1440 pg/ml (normal 10–55). Plain radiographs of the pelvis, left knee and chest demonstrated multiple lucent lesions with sclerotic borders (Figs. 1 and 2). Findings associated with AVN of the left hip also were seen.

Following administration of 20 mCi of ^{99m}Tc-MDP, images were obtained during the flow phase (4 sec/image), immediate blood-pool phase and delayed phase (3 hr) of the exam. The blood flow phase demonstrated a focal area of significantly increased activity in the distal left femur consistent with the location of the lesion seen on the plain radiograph (Fig. 3A). Increased activity was observed immediately during the flow phase with intensity equal to that of the femoral artery. This was felt to be consistent with a highly vascular tumor.

Increased activity was also seen in both the distal left femur and the left acetabulum on the immediate blood-pool and delayed images (Figs. 3B and 4). The delayed images also demonstrated increased activity in other areas including the right femoral neck, right scapula, and multiple ribs bilaterally. The increased activity in the left femoral neck and head was consistent with reactive changes associated with AVN and hypertrophic bone formation.

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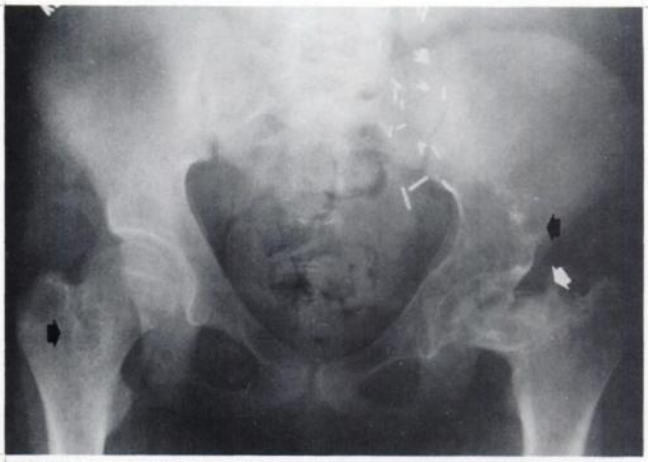

FIGURE 1. AP pelvis. Lytic lesions in right femur and left acetabulum (black arrows). AVN of left hip associated with chronic steroid usage secondary to renal transplant (white arrow). Acetabular lesion represents biopsy-proven brown tumor.

An open biopsy of the left acetabular lesion was performed. At surgery, the cortex of the superior pubic ramus and ilium was thinned. A 4.5 × 4.0 × 2.5-cm dark pink, slightly hemorrhagic tumor was resected. Microscopic examination revealed areas of fibroblasts and histiocytes with scattered clusters of giant cells consistent with brown tumor.

DISCUSSION

Secondary hyperparathyroidism due to parathyroid hyperplasia is associated with chronic renal failure. Plasma calcium levels can be normal or low. The patient can present with soft tissue or skeletal changes which characteristically include bone reabsorption, soft tissue calcification, osteosclerosis, nephrocalcinosis, and brown tumors. Although more often associated with primary hyperparathyroidism, brown tumors are also seen with renal osteodystrophy (secondary hyperparathyroidism). Brown tumors, or osteoclastomas, are highly vascular and may contain necrotic centers. They are well-defined lesions of the axial and appendicular skeleton that can range from purely lytic lesions to sclerotic lesions. Common sites of involvement are the facial bones, pelvis, ribs and femurs (*1*).

The changing manifestations of brown tumors on both bone scans and plain radiographs have been described. One author attributed findings to the reparative phase fol-

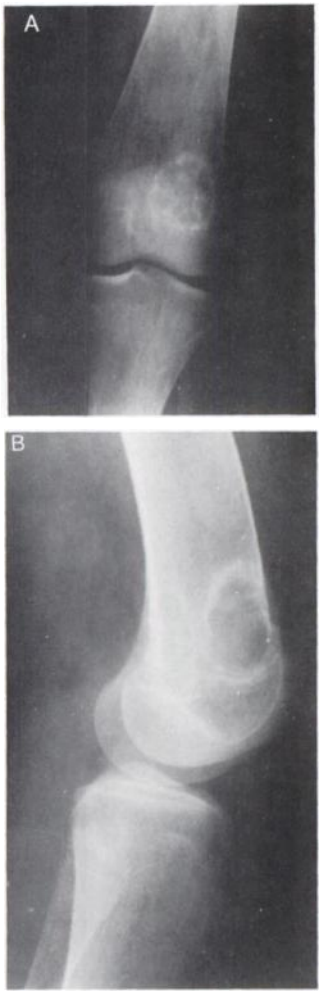

FIGURE 2. AP and lateral views of the left knee. Lytic metaphyseal lesion with a narrow zone of transition.

lowing therapy and the changing number of osteoclasts and osteoblasts secondary to elevated alkaline phosphatase and parathyroid hormone (PTH) (*2*). Osteoid formation, rapid bone turnover, and affinity of bone-seeking agents for nonosteoid organic matrix account for the increased activity on bone scans (*4,5*). The number of osteoblasts has been shown to rise secondary to the long-term stimulus of parathyroid hormone, although PTH characteristically inhibits new bone formation and enhances bone reabsorption (*5*). "A Bone Remodeling Unit" has been proposed to explain both nonsclerotic and sclerotic lesions associated with increased PTH. Nonsclerotic lesions represent an early short-lived reabsorptive phase with increased size of the osteoclast pool, increased bone reabsorption and decreased size of the osteoblast pool. This is followed by a sclerotic lesion with an increased osteoblastic pool (*5*). Therefore, sclerotic brown tumor lesions could represent the healing phases of osseous lesions after therapy or older lesions with an increased number of osteoblasts due to the chronic elevated PTH stimulus.

Uptake of ^{99m}Tc-MDP in osseous structures is directly proportional to regional perfusion, osteoid formation and mineralization (*6*). Therefore, increased activity reflects both blood flow and the healing response. The markedly increased activity seen on the blood flow phase in this case represents the increased perfusion due to the hypervascularity of the brown tumors. The activity seen on the ^{99m}Tc-MDP blood pool and delayed images reflects the degree of bone healing and osteoblastic response.

Other agents can also be used to evaluate this disease. Thallium-201-chloride activity in brown tumors has been investigated. Thallium-201 accumulation is dependent on perfusion, tumor mass and metabolic activity (*7*). Thallium-201 is not a bone-seeking agent, and activity with ^{201}Tl reflects the viable tumor burden, not bone healing. In a study reported by Durak et al. (*7*), it was concluded that ^{99m}Tc-MDP was superior to ^{201}Tl chloride for detection of brown tumors.

In conclusion, this case demonstrates significantly increased accumulation of ^{99m}Tc-MDP on all three phases of a bone scan in a biopsy-proven example of multiple brown tumors associated with secondary hyperparathyroidism. Although the bone scan is nonspecific, in the correct clinical setting brown tumors should be included in the differential diagnosis for focal accumulation of ^{99m}Tc-MDP.

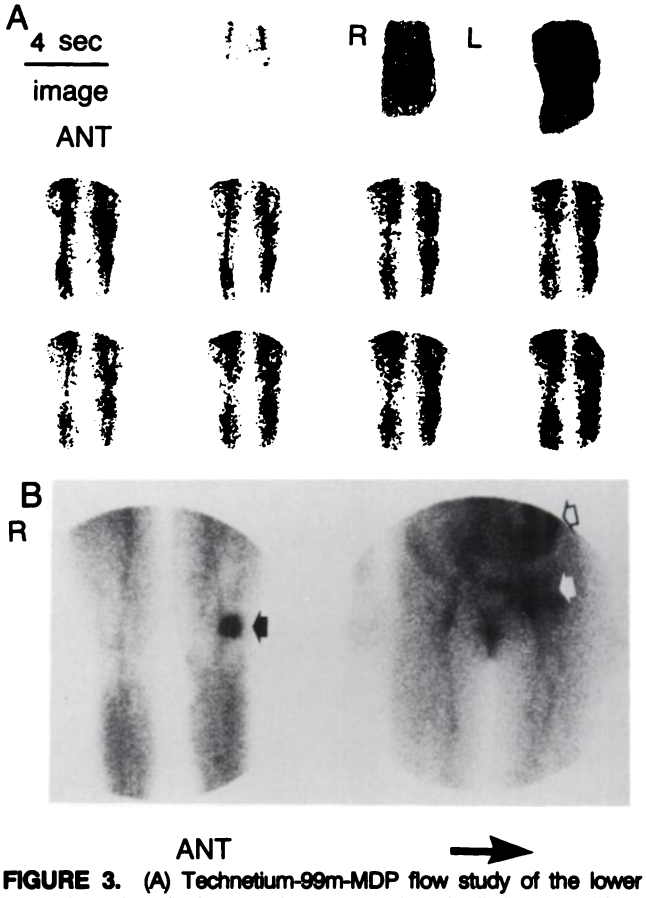

FIGURE 3. (A) Technetium-99m-MDP flow study of the lower extremities. Anterior images demonstrated markedly increased flow to the distal left femoral lesion. (B) Technetium-99m-MDP immediate phase images. Increased activity in the left femoral lesion (black arrow), left hip (white arrow) and left pelvic transplant (arrow head).

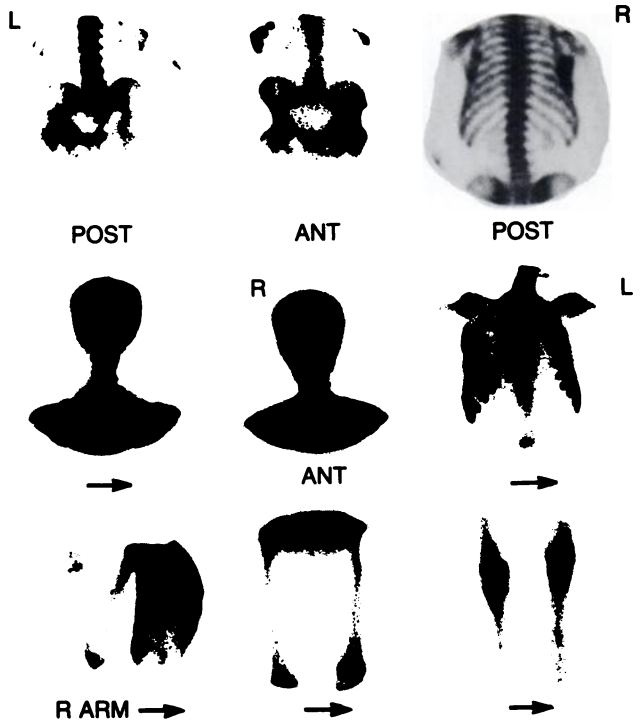

FIGURE 4. Technetium-99m-MDP delayed anterior and posterior images. Increased activity in multiple ribs, right scapula, left acetabulum, left distal femur and right femoral neck representing multiple brown tumors.

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