Update on Pediatric Bone Scintigraphy

Kimberly W. Maas, Gerald A. Mandell, and Colleen A. Buchanan

Alfred I. duPont Institute, Wilmington, Delaware and Du Pont Merck Company, North Billerica, Massachusetts

Radionuclide bone scintigraphy is very helpful to the clinician in detecting and diagnosing many bone and soft tissue abnormalities in the pediatric population. Bone scintigraphy is more sensitive than routine radiographs for subtle changes in bone metabolism. The radiation burden is quite acceptable. Many institutions are hesitant to image children due to lack of experience and knowledge. Although the radiopharmaceuticals and the equipment are essentially the same for adult and pediatric nuclear medicine, children need special attention to certain details and modifications of procedures. Children are not adults, and they have varying diseases and anatomy at different ages.

J Nucl Med Technol 1993; 21:84–88

INTERACTING WITH PATIENT

Just as adults are fearful and suspicious of uncertain situations, so are children. An explanation of the procedure, in terms appropriate for the child's age, is important. This early communication can help to build a rapport between the child and the technologist. A few minutes spent gaining the confidence of a child before the study begins can save time when speedy imaging is crucial.

We schedule our patients in time slots of 30 min for the initial interview, during which we explain the procedure to both parent and child, weigh the child, and perform blood-flow and blood-pool imaging. A good patient history is needed prior to injection of the radiopharmaceutical. This often affects the decision on whether to image a specific area and the order of acquisition sequences. Each case needs to be reviewed individually by the nuclear physician. For delayed images, the patient is scheduled for 2–3 hr of camera time. The length of imaging time depends on the patient's history, the size of the patient, and the number of additional views needed by the nuclear physician. Each planar image takes 3–10 min to acquire. Extra time should be allowed for special views.

For reprints contact: Kimberly W. Maas, CNMT, Alfred I. duPont Institute, 1600 Rockland Road, P.O. Box 269, Wilmington, DE 19899.

INDICATIONS

The value of bone scintigraphy in the pediatric population is early diagnosis of bone disease. The scan may show an increase in radionuclide concentration in patients with arthritis, osteomyelitis, fractures, bone tumors, or inflammatory disorders. The scan may show a decrease in radionuclide concentration in patients with avascular necrosis, bone infarcts, bone cysts, areas of bone involved with radiation therapy, or early osteomyelitis.

Following are indications for a pediatric bone scintiscan.

1. Localization, diagnosis, and evaluation of primary and metastatic bone tumors (chondroblastoma, neuroblastoma, Ewings sarcoma, osteosarcoma, rhabdosarcoma, leukemia, lymphoma (Fig. 1).

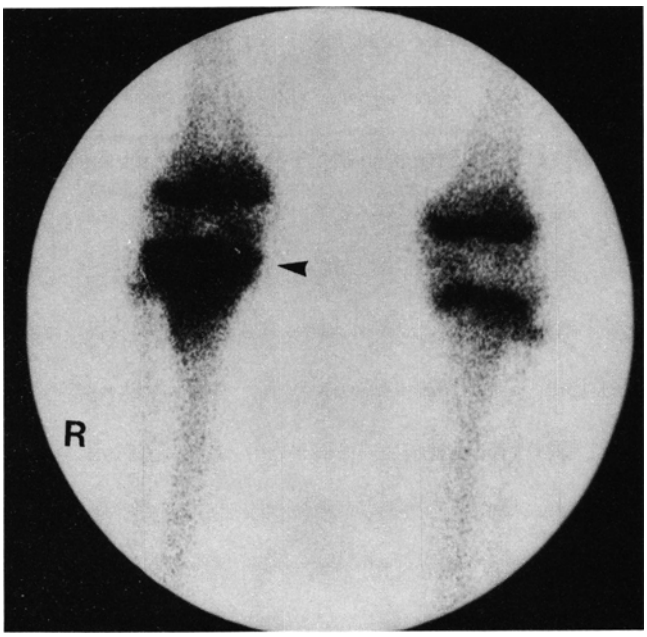

FIG. 1. Delayed image of a patient with a chief complaint of unexplained right knee pain. Arrow shows area of increased localization. The patient underwent a biopsy and was diagnosed with chondroblastoma, a cartilaginous tumor of the epiphysis.

2. Diagnosis and localization of benign tumors, such as osteoid osteomas (Fig. 2).
3. Diagnosis and heterotopic ossification (Fig. 3).
4. Diagnosis of osteomyelitis (Fig. 4).
5. Evaluation of epiphysis or growth plates (Fig. 5).
6. Diagnosis of avascular necrosis and revascularization (Legg-Calvé-Perthes disease).
7. Diagnosis of fractures (stress fractures, toddler's fractures).

MATERIALS AND METHODS

Immobilization

Immobilization is an important part of pediatric bone scintigraphy because of crucial imaging sequences. Children have very short attention spans and need to be reminded of the importance of holding still. Immobilization is necessary for achieving adequate image statistics, which are important for good quality bone scanning. Velcro strips, adhesive tape, sand bags, lead aprons, swaddling, and technologists' hands are good forms of restraint. Meticulous attention during restraint must be paid to avoiding artificial, iatrogenic image defects (*1*). Sedation is rarely used. We use a television and VCR which are effective in entertaining patients from 2–21-yr old for very long periods of time. If sedation is needed, we use 75 mg/kg of chloryl hydrate. This is given by mouth in the form of syrup or rectally in the form of a suppository.

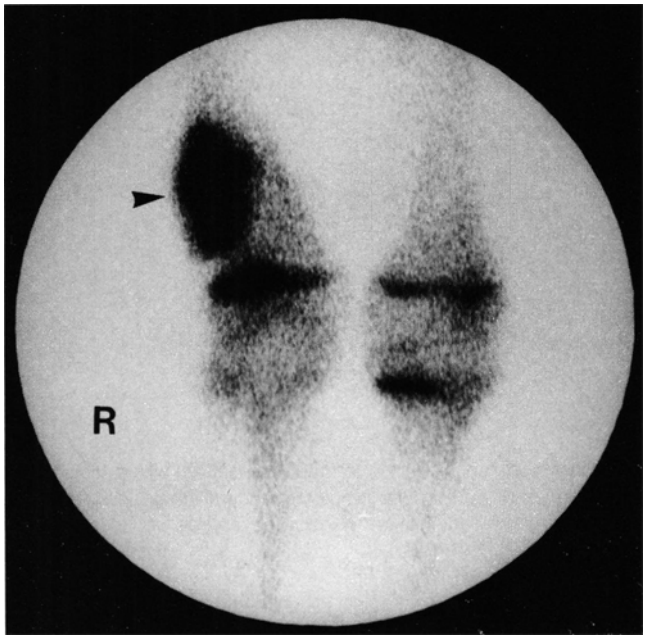

FIG. 3. Anterior delayed bone scintigraphy of the knee was performed on a head trauma patient with knee pain. The arrow indicates an area of increased uptake. This finding is consistent with heterotopic ossification (calcium deposits in the muscle).

Isotope Administration

Technetium-99m methylene diphosphonate (^{99m}Tc-MDP) is the radiopharmaceutical used for bone scintigraphy. The

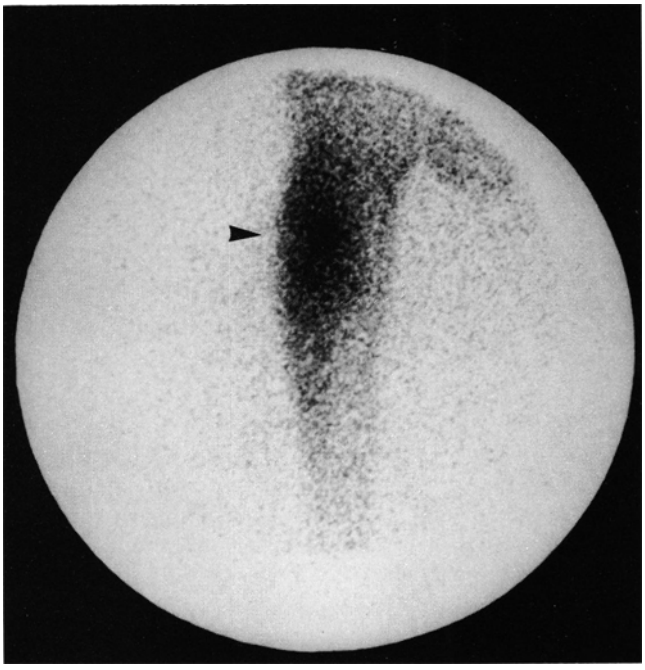

FIG. 2. Pinhole image of the right femur of a patient who had pain in the right thigh area at night; pain was relieved with aspirin. The focal increase in uptake was the nidus or center of a benign osteoid osteoma. The diffuse increase around the tumor represents sclerotic bone tissue. This diagnosis was confirmed surgically.

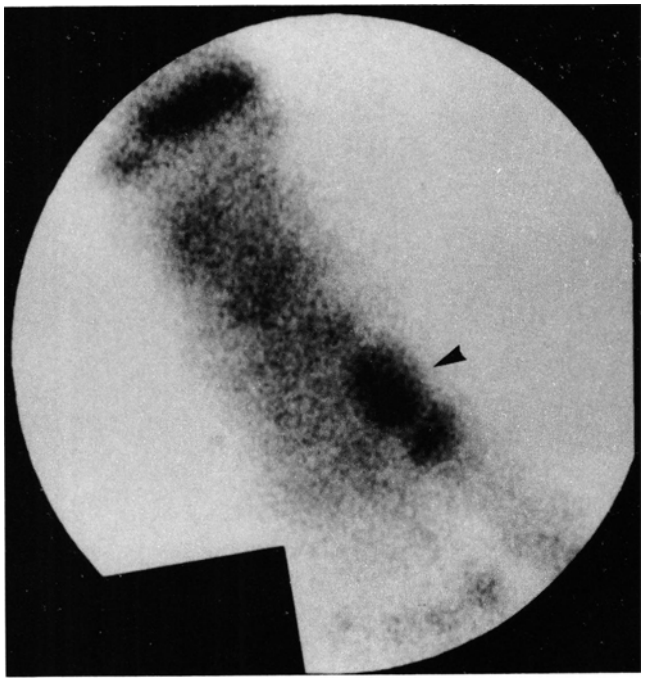

FIG. 4. An anterior pinhole magnification image was acquired on a patient who had foot pain for 1 wk and an increasing sedimentation rate. The arrow indicates an area of increased uptake of the internal cuneiform, consistent with osteomyelitis.

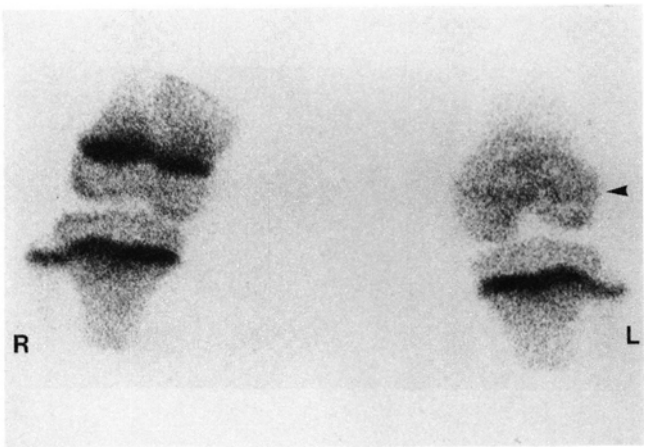

FIG. 5. A bone scan was performed on a patient with a history of a fractured femur and leg length discrepancy. Pinhole images of the knees were acquired. The arrow indicates an area with a decrease in the left femoral epiphysis.

pediatric dose is calculated at 200 μCi/kg (*2*). The minimum dose is 2 mCi and the maximum dose should not exceed 15 mCi. A three-way stopcock is used in conjunction with a 23 or 25-gauge butterfly needle for injection into a hand, wrist, foot, or antecubital vein (*3*).

Imaging Procedure

Blood-flow images, if indicated, are obtained immediately following injection of the radiotracer with the area of interest centered in the field of view (Fig. 6) (*4*). The images are acquired for 2–3 sec per frame, using a general all-purpose collimator (GAP) for a total of 40 frames (20 sec). A 35-mm frame is used.

Blood-pool images of the area of interest are also acquired with a GAP collimator (Fig. 7). A 70-mm frame is used. Upper and lower extremities are imaged in the range of 200–300 k counts, the thorax and pelvis for 300–500 k counts, depending on the size of the patient, and the skull for 200 k counts.

Delayed imaging begins at 2-hr postinjection. To achieve quality images, it is imperative to have the camera as close as possible to the patient. For infant imaging, placing the patient on top of the collimator gives the best resolution. The high resolution collimator is used to attain the best image. Anterior and posterior pelvis and thorax are imaged for 300–500 k counts, depending on patient size, extremities for 200–300 k counts, and skull in the anterior, posterior, and lateral projections for 200 k counts. Infant images are electronically magnified because of the small size, not exceeding

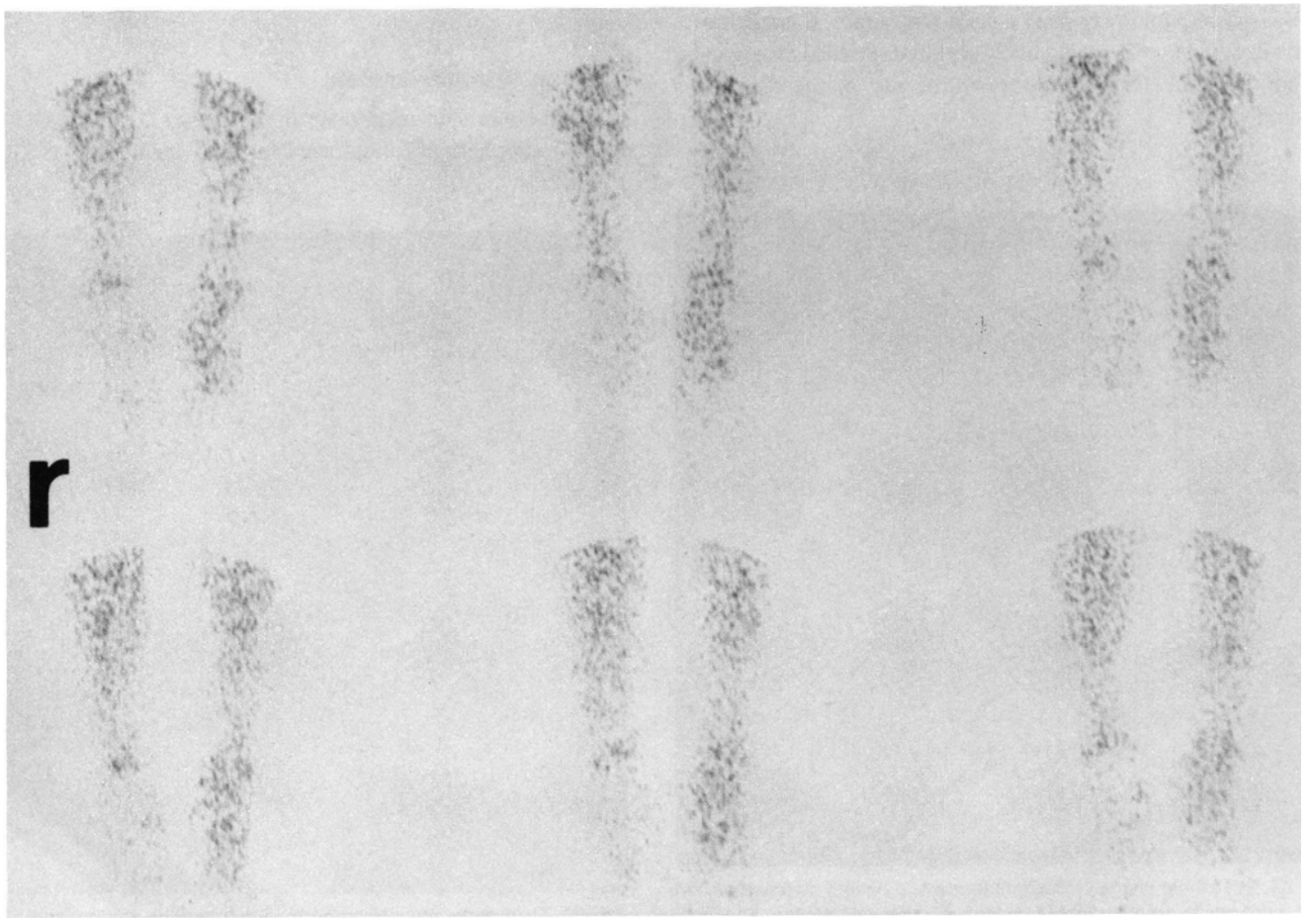

FIG. 6. Blood-flow images of the lower extremities in a patient with a complaint of right lower extremity pain. Radiographs and delayed bone scintigraphs had appeared normal. There is a decrease in activity in the right lower extremity, which could be consistent with reflex sympathetic dystrophy.

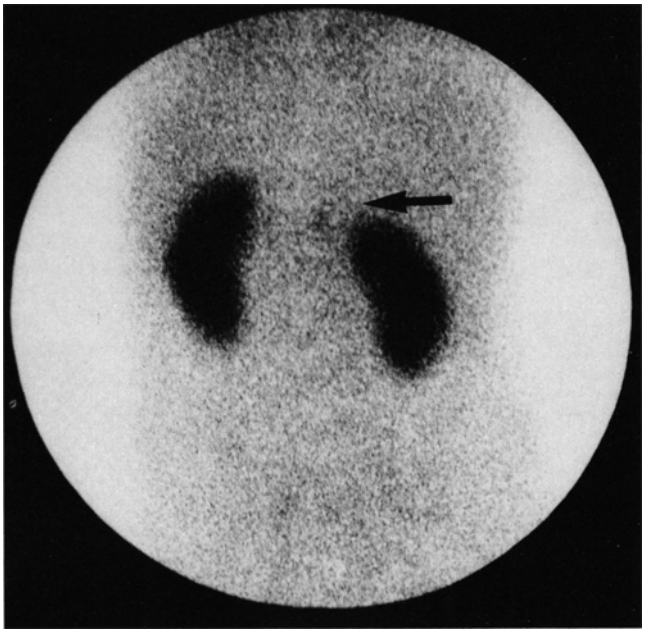

FIG. 7. Blood-pool images of a patient, one year after a spinal fusion and a complaint of back pain, show increased uptake on the blood pool, on the posterior image of the thorax. This indicates that the patient suffers from pseudoarthrosis (false-joint), a deossification of the spinal fusion.

1.6x magnification, to avoid distortion. When imaging the knees, the patient's feet should be internally rotated so as to separate the tibial and fibular epiphysis (*5*).

When imaging trauma patients, it is important to image the posterior thorax with the arms down, and with the arms up,

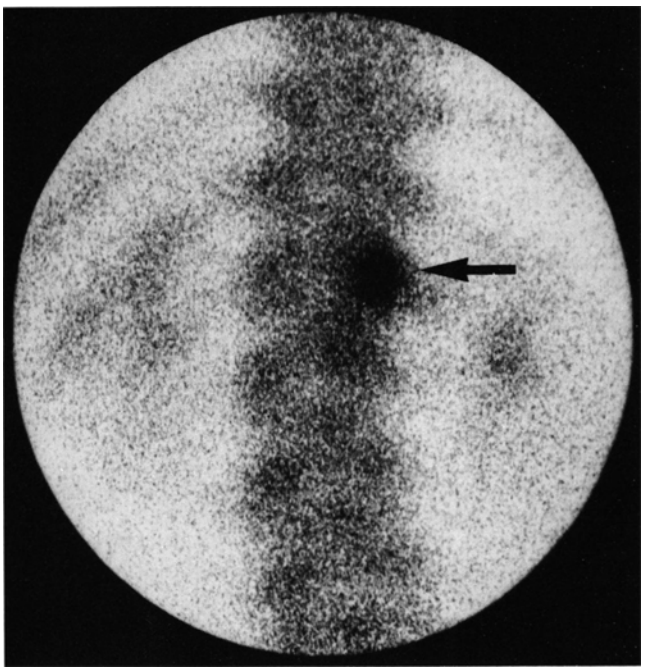

FIG. 8. A pinhole magnification view of delayed bone images of the patient in Figure 7 showed increased uptake, which could be consistent with pseudoarthrosis. Magnification images are needed to localize the region of interest for the physician.

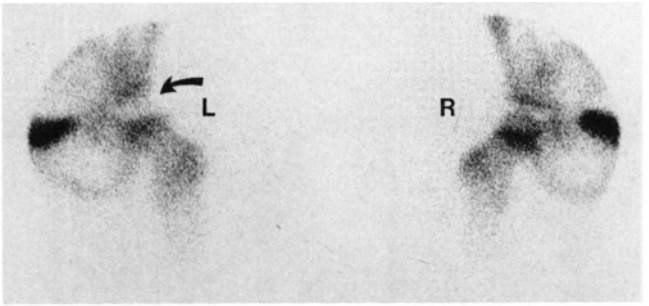

FIG. 9. Pinhole magnification of anterior hips in the neutral position shows decreased uptake of the left head of the femur. This is consistent with Legg-Calvé-Perthes disease. Symptomatic and asymptomatic sides need to be imaged for comparison.

so as to distinguish scapular fractures from rib fractures. Extra views, such as high resolution computer magnification, pinhole imaging, and single-photon emission computed tomography (SPECT) are performed as indicated by the nuclear physician and patient history. High resolution pinhole magnification imaging aids in the detection of avascular necrosis of the hip (Legg-Calvé-Perthes disease) (*6*), localization of small active benign bone tumors (osteoid osteoma) (Fig. 3), and resolution of small fractures in the small bones of the hand and foot.

Pinhole images are acquired for 100 k counts using a 4-mm aperture collimator positioned 4 cm from the surface of the patient (Fig. 8). These images may take from 10 to 20 min per view. Multiple pinhole views are needed for the hips in anterior neutral (Fig. 9) and frog-leg positions (Fig. 10). If the patient is unable to maintain the frog-leg position, the hip is obliqued to visualize the head of the femur. Care must be taken to avoid inclusion of significant counts from the bladder. Knees are usually imaged anteriorly and posteriorly and ankles in anterior and medial lateral positions. Always image the opposite side for comparison. These images may take from 10 to 20 min per view. Counting statistics, in general, for electronic computer magnification are 1.5x the planar statistics.

SPECT imaging is acquired in a 64 × 64 byte matrix for 30 sec per stop with 64 stops in a 360° counter-clockwise rotation. In our institution, these are reconstructed with a medical data systems (MDS) computer, using one pixel per slice

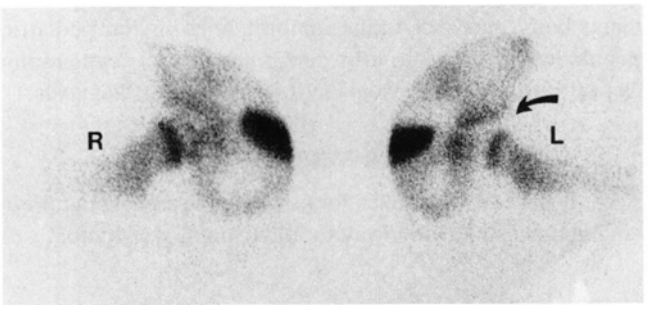

FIG. 10. Pinhole magnifications of the hips of the patient in Figure 9 in the frog-leg position, also showing a different portion of the femoral head. Frog lateral images are used to visualize the medial aspect of the femoral head.

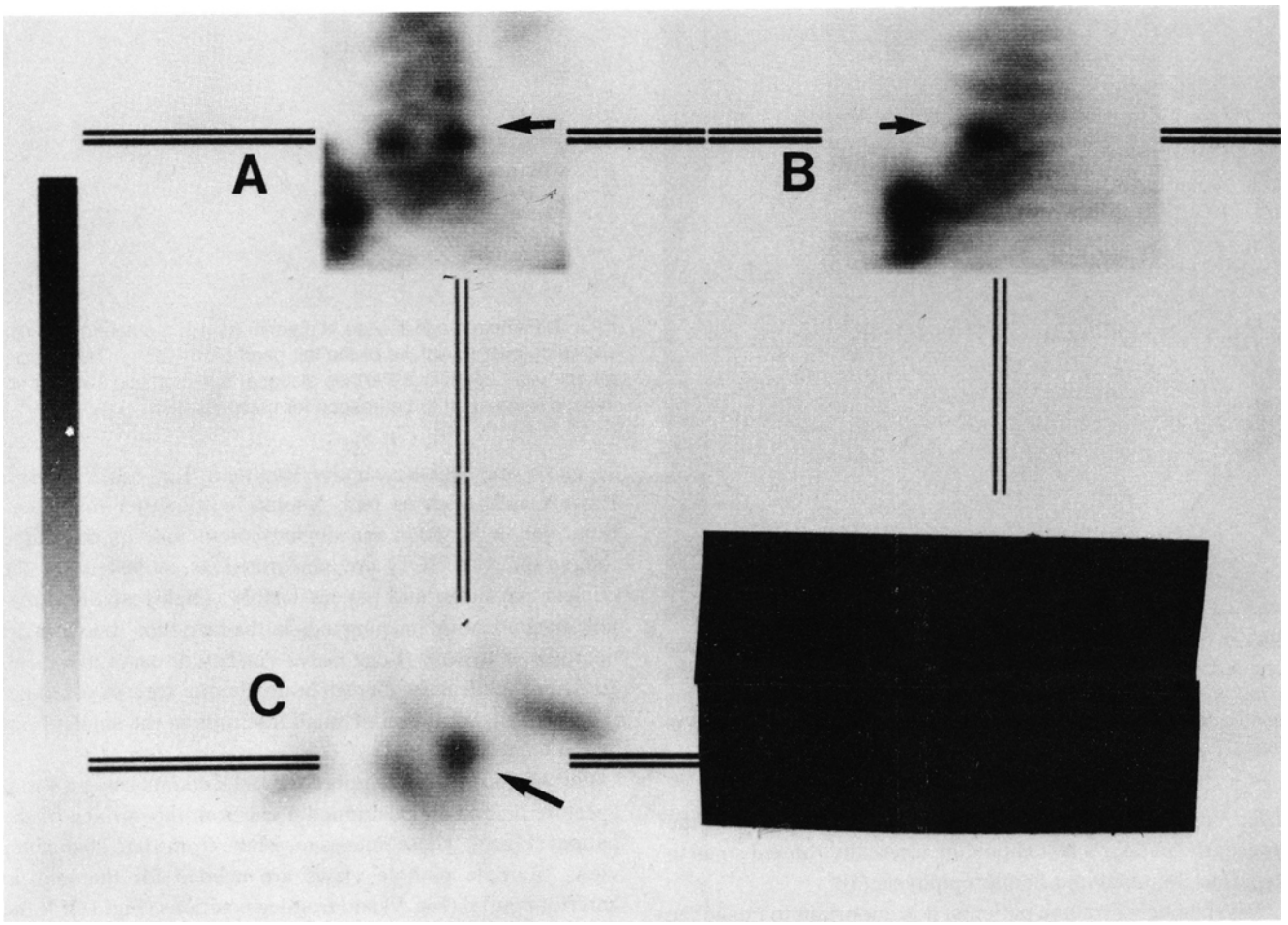

FIG. 11. SPECT images of a patient whose chief complaint is back pain: (A) coronal slices, (B) sagittal slices, and (C) transaxial slices. The arrows indicate areas of increased uptake, which is indicative of spondylolysis, a fracture of the spinous processes. These fractures could be trauma or stress related.

and a Butterworth filter. SPECT is an important tool in determining the etiology of low back pain (Fig. 11), such as spondylolysis and pseudoarthrosis, and for tarsal coalition of the foot (7). SPECT is not very useful near active locations, such as the growth plates or bladder, which may produce scatter defects.

CONCLUSION

Bone scintigraphy is a sensitive noninvasive way to detect many bony and soft tissue abnormalities in the pediatric population. When properly performed, bone scintigraphy can offer the clinician valuable information for diagnosis.

ACKNOWLEDGMENT

We thank Sonia Martinez for assistance in manuscript preparation and Cindy Brodoway for photograph preparation.

REFERENCES

1. Treves ST, Kirkpatrick JA, Conway JB, Turner CS. Introduction. In: Treves ST. *Pediatric nuclear medicine*, 1st ed. New York: Springer Verlag; 1985:XXI–XXII.
2. Treves ST, Kirkpatrick JA. Bone. In: Treves ST. *Pediatric nuclear medicine*, 1st ed. New York: Springer Verlag; 1985:1–6.
3. Harcke HT. *Pediatric nuclear medicine. Diagnostic radiology: a textbook of organ imaging*, vol 3. London: Churchill Livingstone; 1986:2197–2211.
4. Maurer AH, Chen DCP, Camargo EE, Wong DF, Wagner HN, Alderson PO. Utility of three-phase skeletal scintigraphy in suspected osteomyelitis: concise communication. *J Nucl Med* 1981;22:941–949.
5. Harcke HT. Bone imaging in infants and children: a review. *J Nucl Med* 1978;19:324–329.
6. Mandell GA, Keret D, Harcke HT, Bowen JR. Chondrolysis: detection by bone scintigraphy. *J Pediatr Orthop* 1992;12:80–85.
7. Mandell GA, Harcke HT, Hugh J, Kumar JS, Maas KW. Detection of talocalcaneal coalitions by magnification bone scintigraphy. *J Nucl Med* 1990;31:1797–1801.