Volume Three-Dimensional Display of Bone SPECT Images

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To assess the diagnostic usefulness of the volume three-dimensional (3-D) display in bone image interpretation using a triple head gamma camera, we studied technetium-99m hydroxyl methylene diphosphonate bone studies of 41 patients referred for bone metastasis, low back pain, or other conditions. In addition to planar images, SPECT images of the skull, cervical vertebrae, thoracic vertebrae, lumbar vertebrae, or pelvis were obtained. The processing time for the volume 3-D display was 5–10 min upon completion of the SPECT image. Volume 3-D display of each study was read along with planar and SPECT images. Volume 3-D display facilitates perception of regional abnormalities and lesions. The enhancement of 3-D perception by motion appears to be an inherent characteristic of the human perceptual system. We conclude that 3-D display enhances interpretation of bone SPECT images and may be an essential part of the interpretation of SPECT images.

Radionuclide bone imaging is one of the most common procedures in daily nuclear medicine practice because it is a very sensitive test, which can demonstrate changed bone pathophysiology before the lesion is visible by radiographic imaging. However, one of the limitations of the bone scan is related to uptake within overlying bony structures. Lesions of the skull or facial bones, for example, may be difficult to localize in a precise anatomical site. Single-photon emission computed tomography (SPECT) has increased detectability of lesions in the vertebrae for back pain (*1,2*). SPECT provides the advantage of improved image contrast by separating overlapping structures. However, there is sometimes difficulty in following structures from one slice to the next, making interpretation of transaxial, coronal, and sagittal sections more complex and difficult than with the use of planar images. Volume three-dimensional (3-D) display enhances the continuity of structures and understanding of spatial relationships through observation of the lesion from all angles (*3–5*). We undertook this study to assess the utility of volume 3-D display in bone image interpretation of the skull; lumbar, thoracic, and cervical vertebrae; or pelvis.

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MATERIALS AND METHODS

Forty-one consecutive patients presenting for metastatic workup, back pain, or other conditions underwent bone imaging. Each patient received an intravenous injection of 20–25 mCi of technetium-99m hydroxyl methylene diphosphonate (^{99m}Tc-HMDP). An anterior total body bone image was obtained 2–3 hr after IV injection of the radiopharmaceutical, using a Siemens Orbiter gamma camera (Siemens Gammasonics, Schaumburg, IL). Subsequently, posterior and anterior "spot" images were obtained. SPECT images were obtained with a triple head camera (Prism, Picker International, Cleveland, OH), interfaced with a 64-bit supercomputer from the following sites (depending on the lesions suspected): skull; cervical, thoracic, and lumbar vertebrae; and pelvis. Planar and SPECT bone images were interpreted comparatively. Acquisition time of each SPECT ranged from 20–25 min and processing time of the volume 3-D was 5–10 min. SPECT images included coronal, sagittal, and transaxial sections. Volume 3-D was viewed as a cine display.

RESULTS AND DISCUSSION

In addition to routine planar bone images, SPECT images were obtained at the following sites: skull/facial bones (4), cervical vertebrae (4), thoracic vertebrae (4), lumbar vertebrae (21), and pelvis (8). Skull lesions were well localized by transaxial, coronal, and sagittal SPECT images. As expected, SPECT images provided a clearer interpretation than planar images. It was easy to discriminate and differentiate skull lesions from intracranial lesions. However, it was difficult to localize lesions in the skull by SPECT sections.

Volume 3-D displays provided the ability to identify the exact location of skull lesions (Fig. 1) and also allowed easier correlation of the lesions. Figure 1 illustrates that skull lesions of a 59-yr-old man with leiomyosarcoma of the stomach were easily identified by volume 3-D, while the lesions were difficult to localize on sagittal or transaxial slices.

Scapular lesions are difficult to differentiate because the scapula overlaps with the upper ribs posteriorly. Thus, on planar images, lesions may appear to be in the scapula or in the underlying rib. SPECT and volume 3-D display provide this differentiation as illustrated in Figure 2.

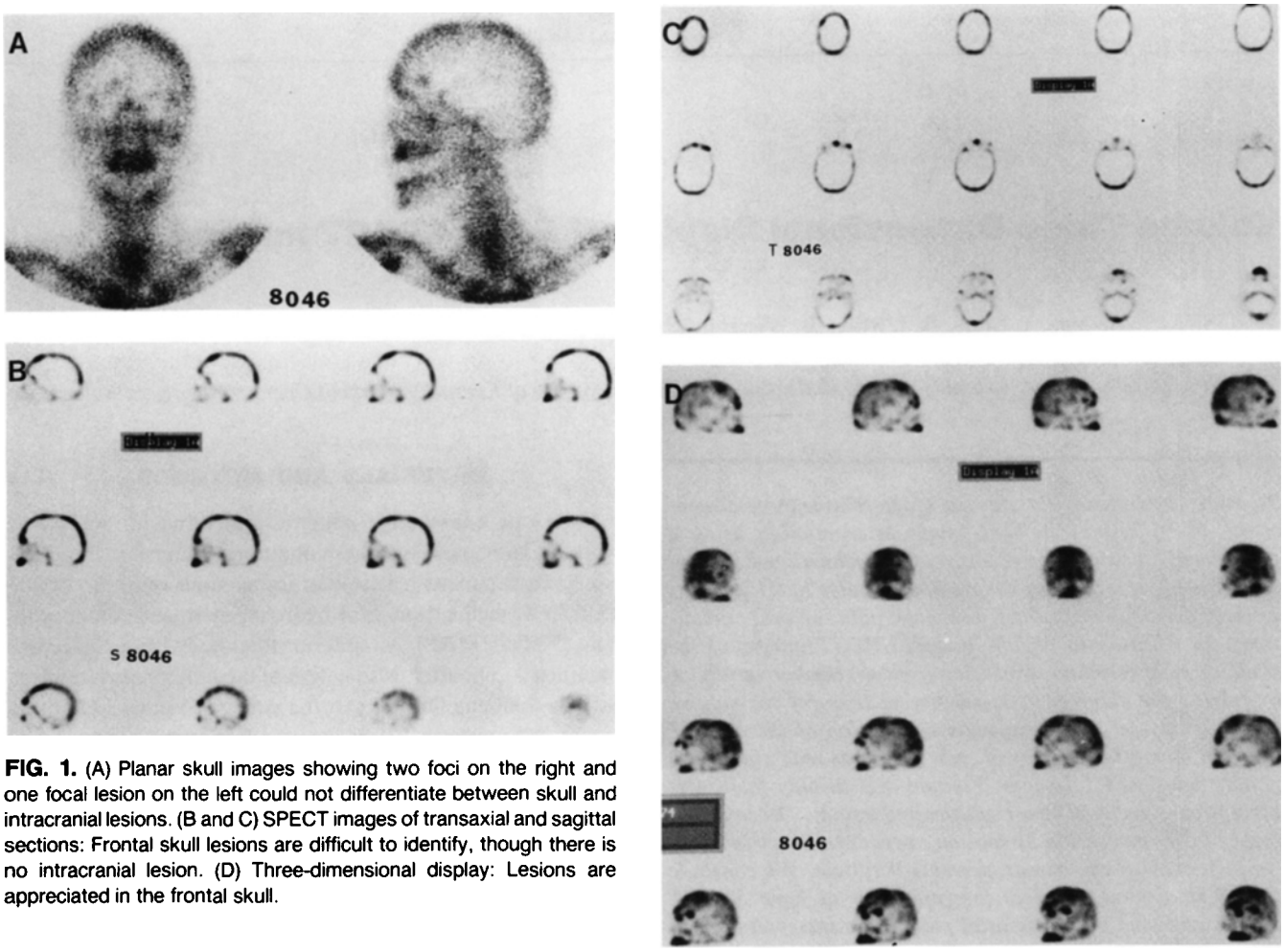

FIG. 1. (A) Planar skull images showing two foci on the right and one focal lesion on the left could not differentiate between skull and intracranial lesions. (B and C) SPECT images of transaxial and sagittal sections: Frontal skull lesions are difficult to identify, though there is no intracranial lesion. (D) Three-dimensional display: Lesions are appreciated in the frontal skull.

One mandible defect of a bone graft was difficult to identify by SPECT images (transaxial, coronal, and sagittal) but was well detected by volume 3-D display (Fig. 3). Filling-in of the previously noted defect on the 17th postgraft day was well demonstrated by volume 3-D display (Fig. 3).

Two lumbar lesions and one thoracic vertebral lesion were detected by SPECT but not by planar images (Fig. 4). Transaxial sections of vertebrae are generally difficult to interpret, compared to sagittal and coronal sections; however, vertebral lesions are easily identified by volume 3-D display, either on films or on cine display.

Urinary bladder activity (especially in those patients who empty their bladders) might interfere with SPECT processing as shown in Fig. 5.

SPECT imaging has allowed more accurate visualization of organ structures to detect small lesions. At the same time, image interpretation has become more complex; the viewer must deal with increasing numbers of images to synthesize a mental picture of whole organs in this report (bone) from a display of many slices. Three-dimensional perception by motion appears to be an inherent characteristic of the human perception system (*3–5*). Surface 3-D display of the brain has been used effectively to diagnose cerebral disease processes. It is recognized that utilizing 3-D display easily identifies the location and extent of the lesions without searching through a large number of SPECT images (*6*).

CONCLUSION

Volume 3-D display is certain to enhance bone lesion identification because 3-D display provides continuity of structures and integrates spatial relationships to present views of the lesions from all angles (*3–5*). We concur that volume 3-D display, though not providing new information, gives faster and more confident interpretation of SPECT images (*5*). In conclusion, volume 3-D display strengthens interpretation of SPECT bone lesions and should become an essential part of the interpretation of SPECT images.

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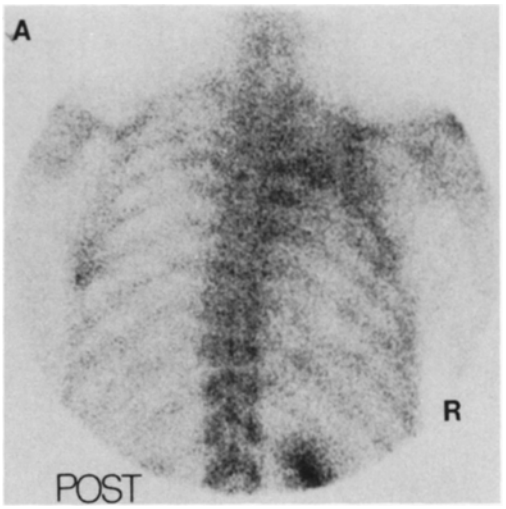

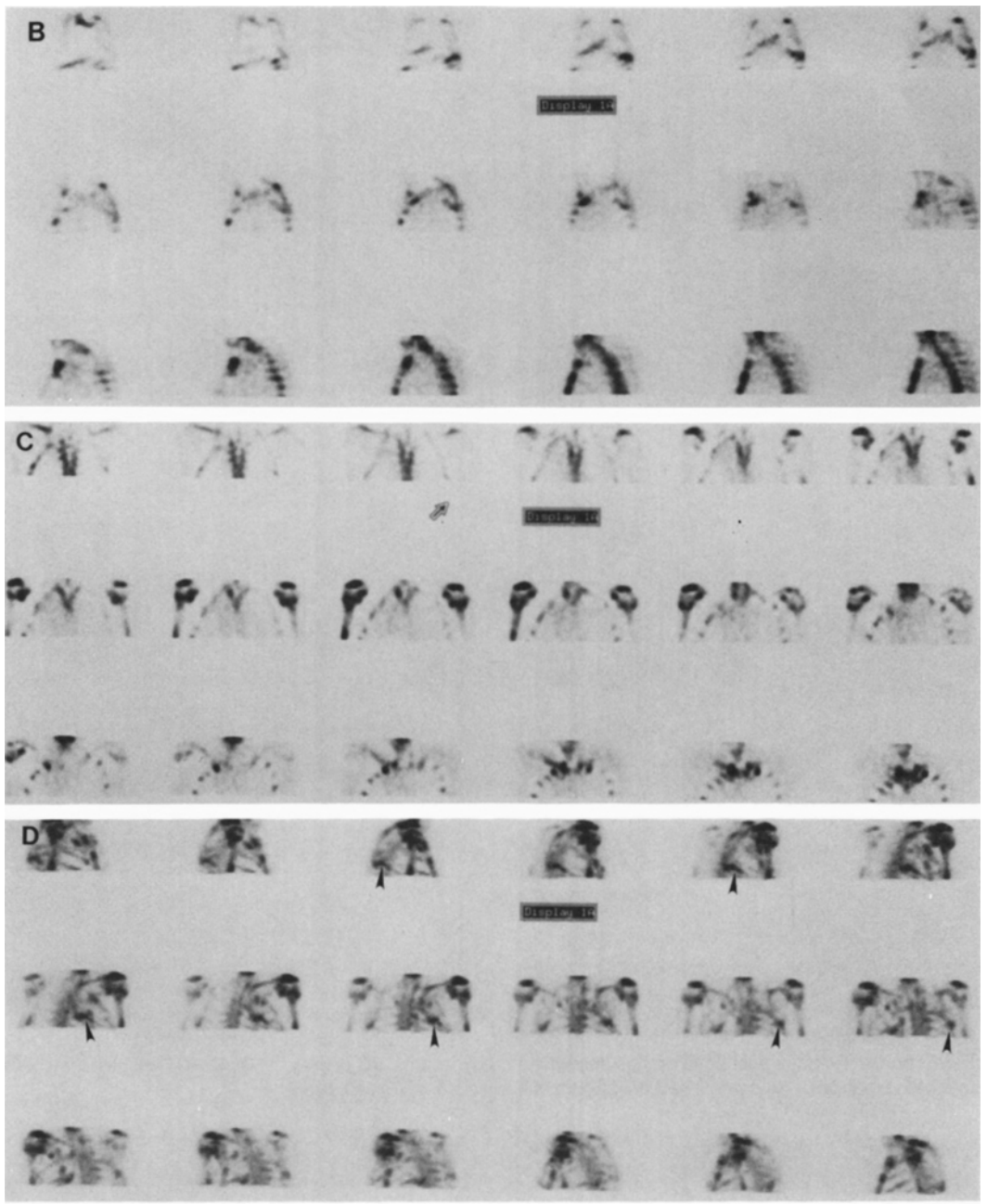

FIG. 2. Planar and SPECT images of the thoracic cage of a 58-yr-old man post right upper lung lobectomy for squamous cell carcinoma of the lung with complaint of back pain: 3-D display provides faster and more confident interpretation that the lesion is in the scapula (arrow heads).

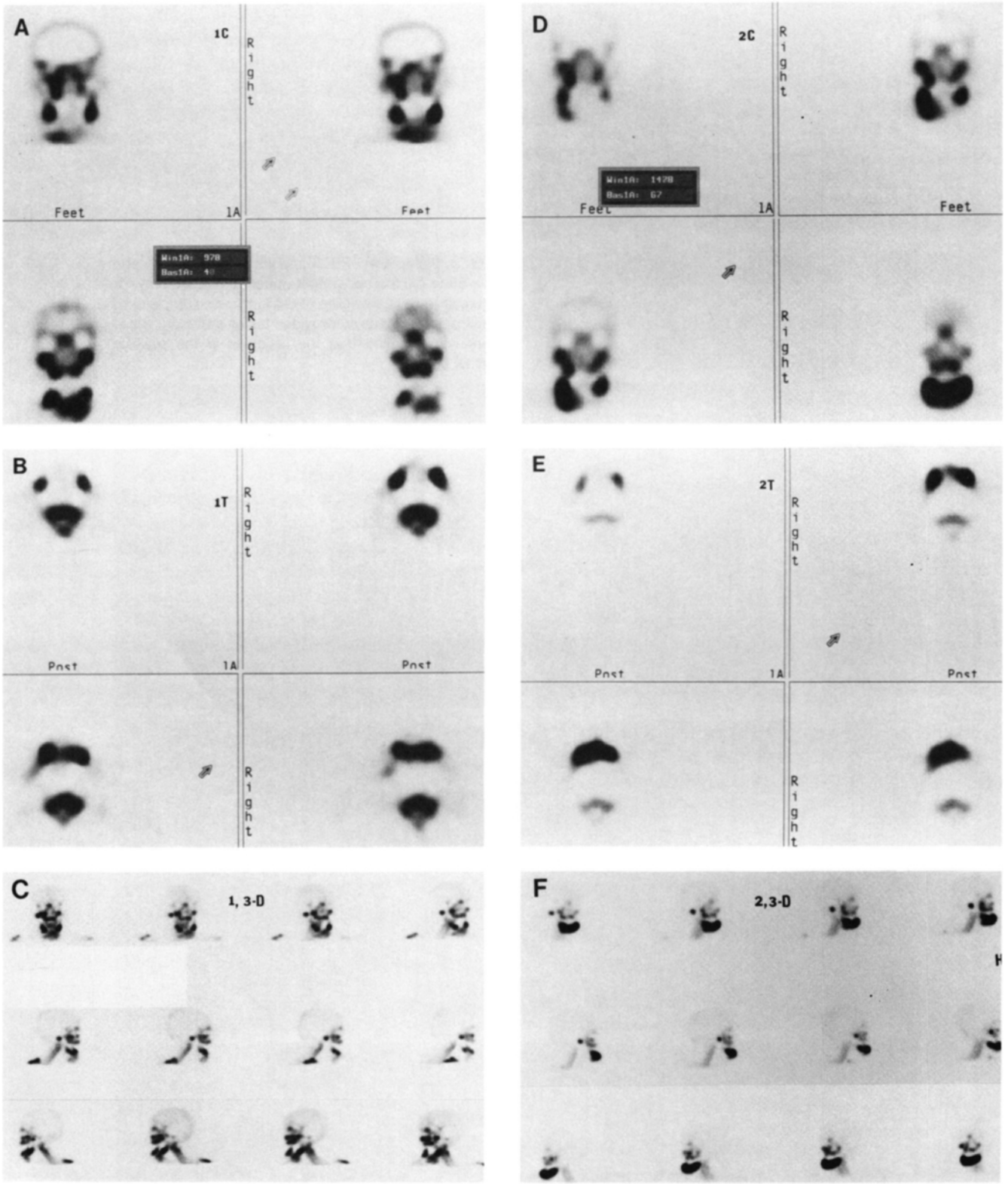

FIG. 3. (A–C) A 61-yr-old man, first postoperative day after mandible bone graft. The bone defect of the mandible is difficult to assess by SPECT images, but is appreciated by volume 3-D display: (A) coronal sections; (B) transaxial section; (C) 3-D display. (D–F) Fill-in of the previously noted defect on the 17th day post bone graft is demonstrated by volume 3-D display, while SPECT images show a "defect" due to anatomical curvature of the mandible: (D) coronal sections; (E) transaxial sections; (F) 3-D display.

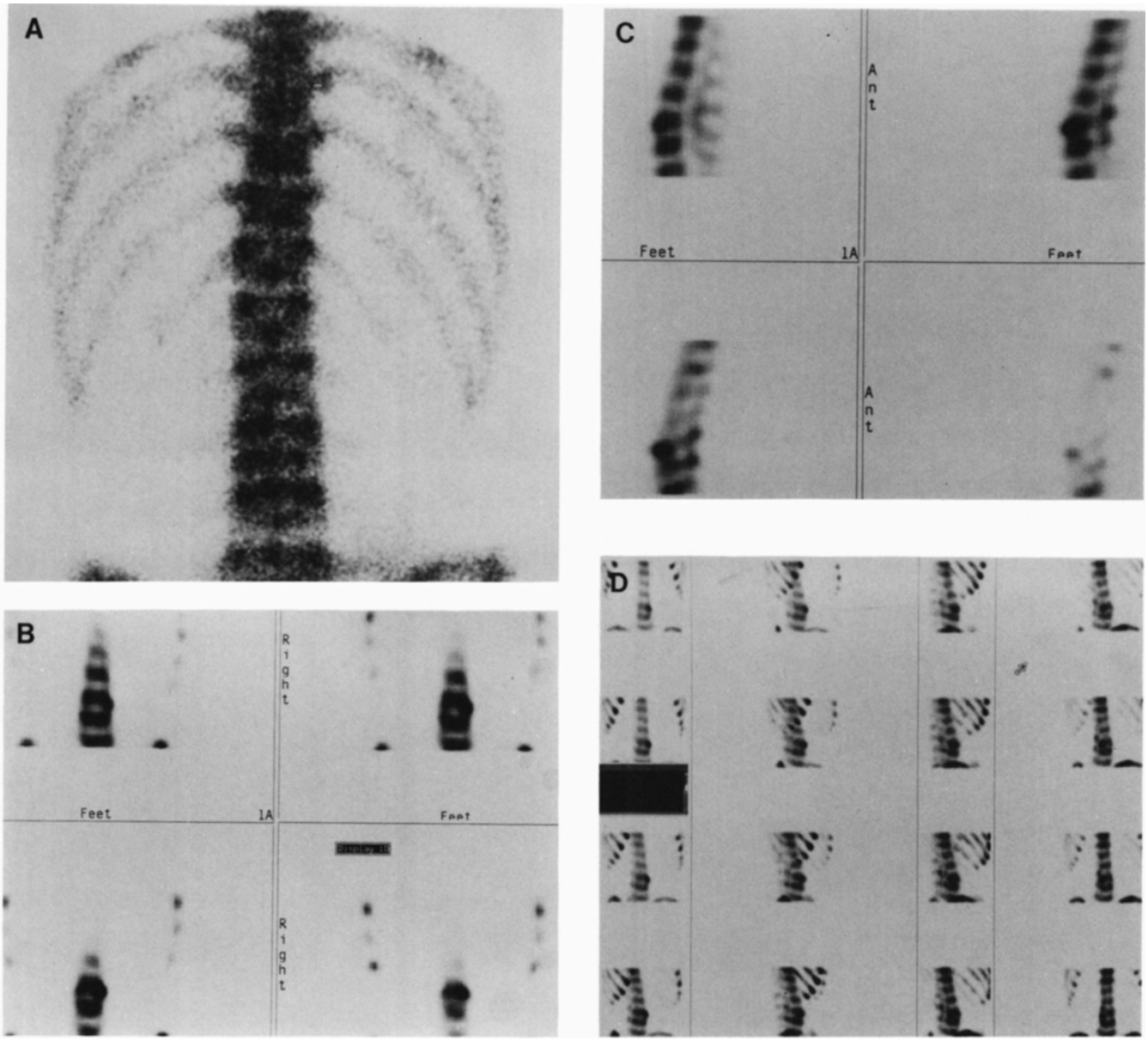

FIG. 4. A 35-yr-old man with low back pain. (A) Posterior planar image of the spine shows no abnormal area of increased uptake in the vertebrae. (B and C) Selective sagittal and coronal sections show a focal area of increased uptake in the L3 vertebra. (D) Three-dimensional display demonstrates the lesions to the adjacent normal L3 vertebra; it was confirmed that this represents spondylolysis of L3.

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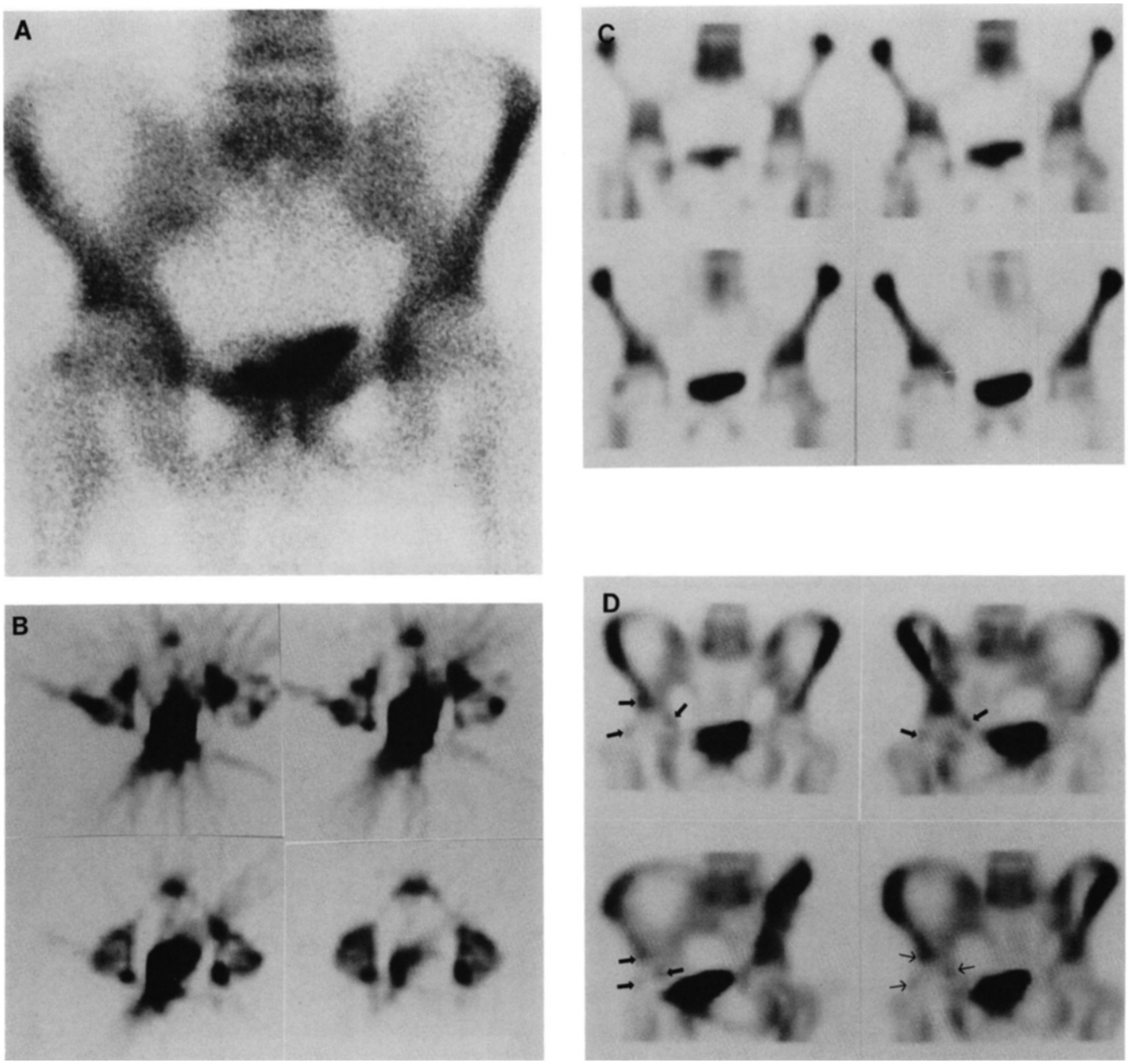

FIG. 5. A 46-yr-old man with recent 10-lb body weight loss and right pleuritic pain. Planar (A) and SPECT (B and C) images show three foci of increased uptake near the right hip: One in the superolateral acetabular roof, one in the region of the femoral neck, and one in the inferomedial portion of the acetabulum. These three foci (arrows) are well demonstrated in the volume 3-D display (D). Notice that the bladder activity in the transaxial section may interfere with interpretation of transaxial sections (B).