Bone Scanning with ^{99m}Tc-Labeled Products

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Since its acceptance into the family of nuclear medical procedures, bone scanning has been able to accurately localize centers of new bone growth, as related to various diseases, somewhat earlier than conventional radiographic procedures (*1*). In its evolution, bone imaging has experienced many changes in the use of various byproduct material and has involved a wide range of techniques. Early results obtained in bone imaging were of sufficient quality to suggest continuance, further development, and research which have recently produced "bone-seeking" reagents that can be labeled to ^{99m}Tc (*2*).

Sodium pertechnetate labeled to stannous polyphosphate (^{99m}Tc-SNPP) and diphosphonate (^{99m}Tc-EHDP) are among the more recent advances in agents that will accumulate in most neoplastic bone lesions and permit positive identification long before decalcification occurs. In addition to the detection of primary and metastic lesions, the bone scan is useful in assessing arthritis, gout, and the staging of various lymphomas. Radiotherapists find bone scans useful for accurate localization of areas in need of treatment.

There are distinct advantages in using technetium-labeled radiopharmaceuticals instead of radionuclides of strontium or fluorine. The technetium is generator-produced in the laboratory, can be tagged with commercially available kits, is ideal for either rectilinear scanners or gamma cameras, can be given in large doses, and does not require lengthy delays between the injection and scan times. The only disadvantage is its clearance by the kidneys and excretion into the urinary bladder (*2*).

Strontium-85 can not be given in doses large enough to permit the accumulation of sufficient information. It is unadvisable to scan less than 3 days following injection, and it is suggested that a week is optimal. Accumulations of ^{85}Sr in the colon require cathartics and cleansing enemas. No patient without proven carcinoma may be injected with this radiostrontium (*2*).

Strontium-87m is available from a generator and has a physical half-life of 2.7 hr. Doses higher than those with ^{85}Sr can be given, but the short half-life requires scanning to be done before significant elimination of the isotope from the blood.

The most significant disadvantage of ^{18}F is that it is reactor produced and has an extremely short physical half-life. Therefore, the scanning laboratory must be located near a reactor facility (*3*).

A comparison of the characteristics of the most common "bone-seeking" agents is given in Table 1.

There are two labeling kits for each of the reagents commercially available from three companies. Technetium-99m diphosphonate is prepar-

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Table 1. Comparison of Common Bone-Scanning Isotopes

Isotope	Half-life	Principle energy (keV)	Usual dose	Dose-to-scan time	Instrument	
					Camera	Scanner
^{85}Sr	65 days	514	100 μCi	3–7 days	N.R.*	X
^{87m}Sr	2.7 hr	388	1–4 mCi	1–3 hr	X	X
^{18}F	1.85 hr	511	1–5 mCi	2–4 hr	X	X
^{99m}Tc–SNPP	6.0 hr	140	10–15 mCi	2–4 hr	X	X
^{99m}Tc–EHDP	6.0 hr	140	10–15 mCi	2–4 hr	X	X

*Not recommended

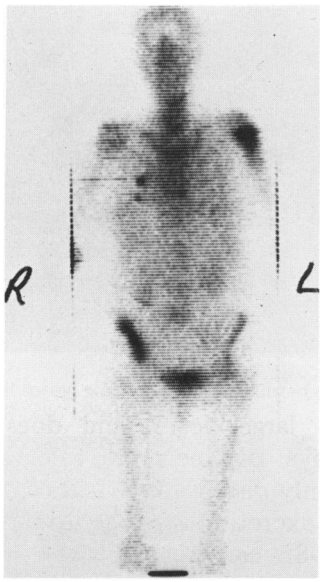

FIG. 1. Anterior, 5:1 miniscan.

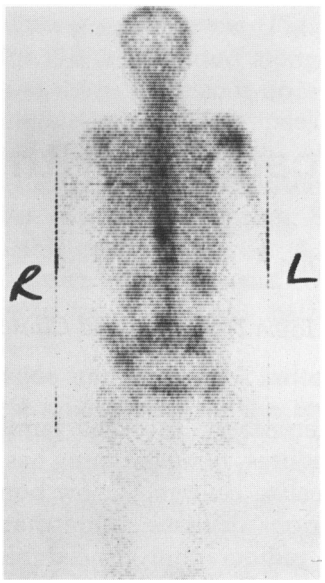

FIG. 2. Posterior, 5:1 miniscan.

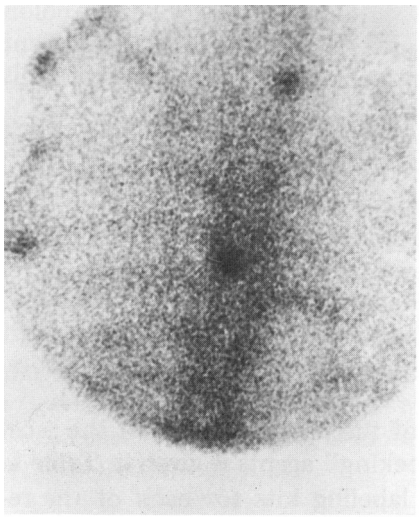

FIG. 3. Posterior, dorsal spine.

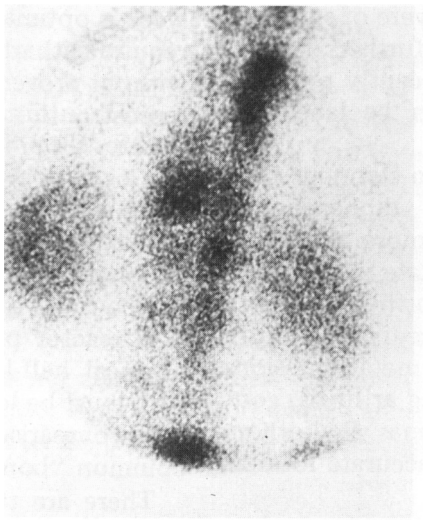

FIG. 4. Posterior, midspine.

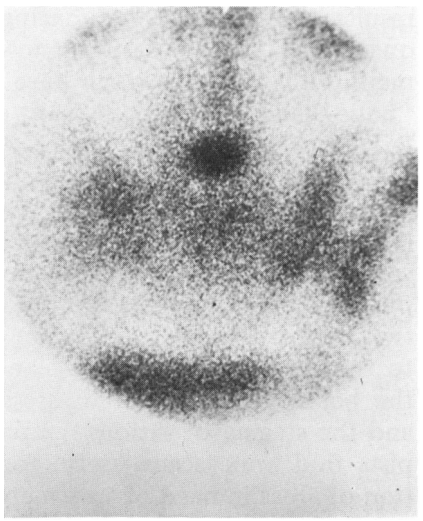

FIG. 5. Posterior, sacrum.

ed by adding 2-5 ml of pertechnetate solution to a reagent vial and mixing for 1-2 min or until the lyophylized powder is disolved (*4*). Another method for labeling is to add one part, by volume, of reagent to form one to eight parts, by volume, of oxidant-free ^{99m}Tc-pertechnetate and mix thoroughly. Labeling is instantaneous and immediately ready for intravenous injection. To prevent oxidation of the labeled reagent, air should not be injected into the vial, and "wet" alcohol should not be present on the rubber stopper during mixing and withdrawal *(5)*. No material may be used 4 hr after mixing *(4,6)*.

Polyphosphate is prepared by adding from 3 to 5 ml of ^{99m}Tc-pertechnetate to a reagent vial and mixing thoroughly; hand shaking is sufficient for 2 min. The ^{99m}Tc is instantly labeled and is ready for immediate injection. The material may be injected as late as 8 hr after mixing (*4,7*).

A usual adult dose of 10-15 mCi of ^{99m}Tc-SNPP or ^{99m}Tc-EHDP is administered intravenously 3-4 hr before scanning. The kidneys excrete a large portion of this material. The patient should be encouraged to drink fluids and void frequently during this time to reduce radiation exposure to the bladder. The patient is also requested to void just before scanning to avoid concentrations of urine in the bladder.

Whole-body scanners with minification circuitry are ideal. Collimators with 5-in. focal depths are preferred but not necessary. The patient should be properly positioned on a scan table, and a deter-

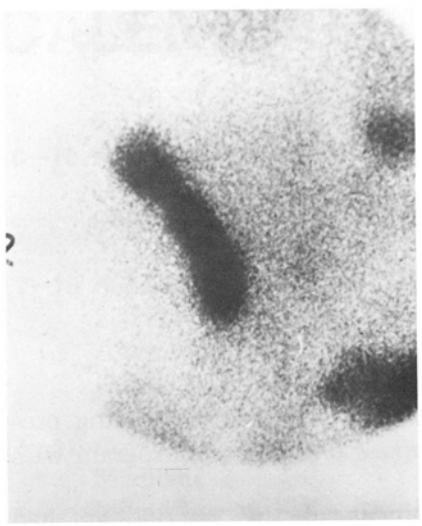

FIG. 6. Anterior, right pelvis.

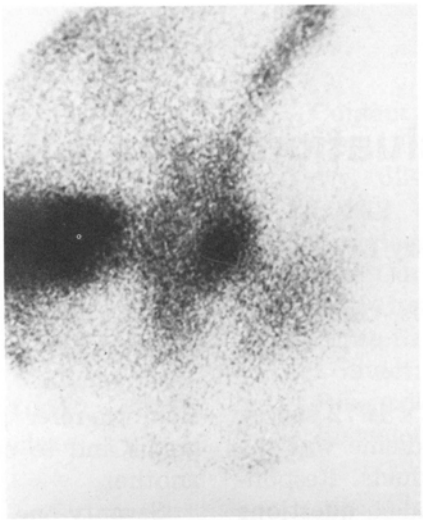

FIG. 7. Anterior, left pelvis.

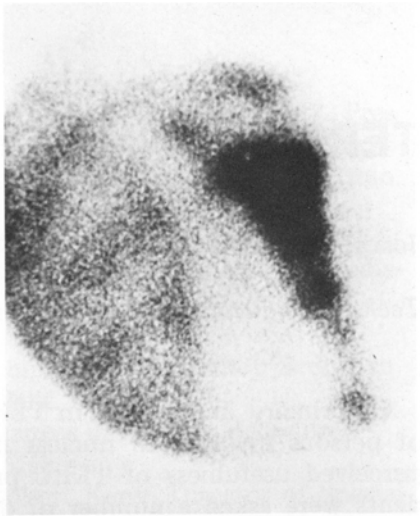

FIG. 8. Anterior, left shoulder.

mination of maximum counting rate made. Usual areas of high accumulation are the spine, sacrum, pelvis, or sternum. Be careful not to use the bladder area for determination of maximum counting rate. The scan is begun at midthigh and done cephlad to allow the bladder to be scanned fairly early before further accumulation of radioactivity occurs. When the entire trunk and skull have been scanned, the detector is returned to the point in midthigh, and the lower extremities are scanned.

After a review of the miniscans, further evaluation of areas of increased activity can be made with a conventional 1:1 rectilinear scan or with scintiphotos from the gamma camera. The gamma camera high-resolution collimator designed for ^{99m}Tc will produce very high-resolution images. An accumulation of 300K counts for extremity joints and 400K counts for skull, thorax, abdomen, and pelvis is sufficient. The usual time required to accomplish each view is between 3 and 5 min.

Case

This patient had a radical mastectomy with a course of radiotherapy for breast carcinoma in 1971. She returned with pain in the chest and dorsolumbar spine, and a bone scan was indicated.

Figures 1 and 2 show areas of increased uptake indicative of metastatic disease in the left shoulder, right iliac crest, right hemithorax, sacrum, and dorsolumbar spine. On closer examination, these areas of probable metastatic involvement were imaged and a better assessment of the involvement was provided with gamma camera imaging as illustrated in Figs. 3-8.

Technetium-99m bone scans are very practical and easily accomplished. Concise and consistent results for evaluation of bone diseases can be found causing very little patient delay and no appreciable discomfort.

Acknowledgment

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References

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