

Bone Imaging Techniques Using ^{99m}Tc -Labeled Compounds

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Over the past few years, bone imaging has been a tremendous problem, primarily because of the limited number of isotopes that were available and the lack of adequate instrumentation. When we were confined to the use of ^{85}Sr and the rectilinear scanner, only a partial or limited examination could be performed and required 2 or 3 days after the injection of the isotope, which was restricted to 100–299 μCi , and then 2–4 hr of scanning time for the patient. The last 2 or 3 years have opened the door to performing accurate and relatively fast bone imaging procedures. Fluorine-18, a reactor- or cyclotron-produced isotope with a short, 2-hr half-life was regarded as a breakthrough for bone imaging for several reasons. First, it allows the examination to be performed the same day,

usually after a 1- or 2-hr wait postinjection, and second, the gamma camera can be used with either a pinhole collimator or a high-energy collimator, or both. This provides images that are satisfactory and one can easily survey the entire skeletal system in about 1 hr.

In late 1972, stannous polyphosphate and sodium diphosphonate tagged with ^{99m}Tc were introduced for skeletal imaging. The distinct advantage to using a ^{99m}Tc -labeled compound is the 140-keV energy of ^{99m}Tc which is ideal for the gamma camera with its relatively thin $\frac{1}{2}$ -in.-thick NaI(Tl) crystal in a detector head.

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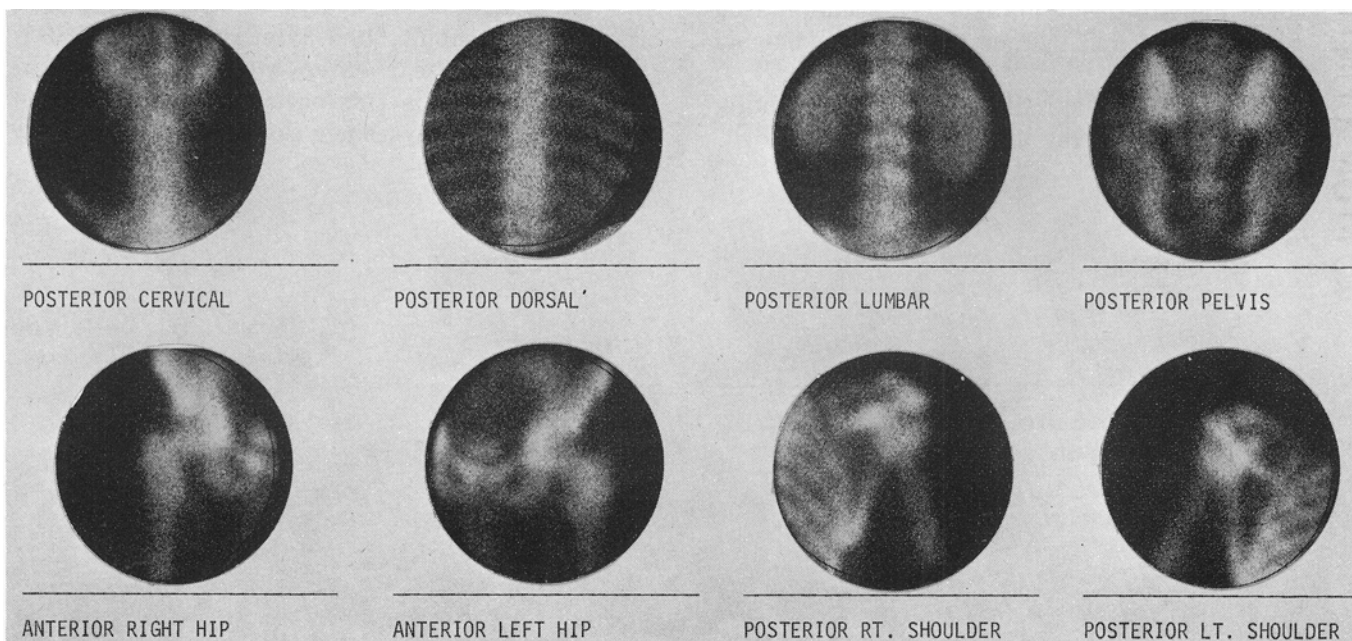


FIG. 1. Study of normal person. All bones show homogeneous uptake without any evidence of increased activity.

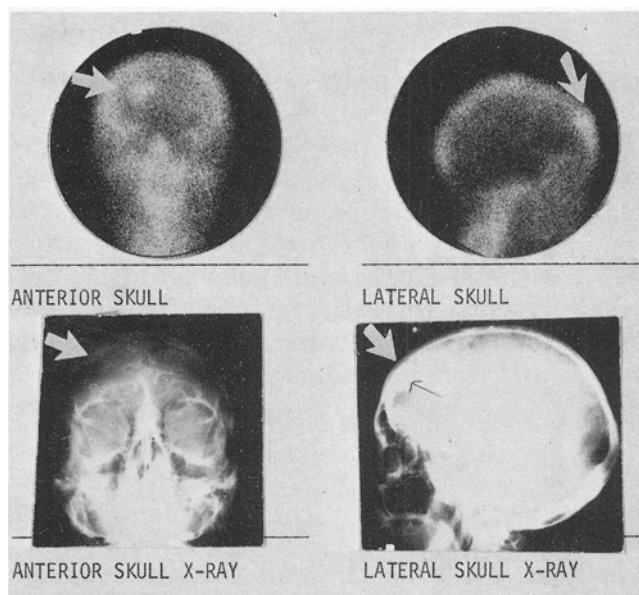


FIG. 2. Study of patient with metastatic disease from primary carcinoma. Note increased activity in right frontal area of skull and several other areas of increased activity in pelvis, spine, and shoulder.

Performing Bone Scans

After the intravenous administration of the ^{99m}Tc -polyphosphate or diphosphonate, it is cleared rapidly from the blood through the renal or urinary system and by deposition in the bone. Usually 30–60% of the polyphosphate compound is cleared by the kidneys within 6 hr and approximately 40–50% of the injected material is accumulated in the skeletal system. The diphosphonates seem to clear more rapidly and give a little less kidney-to-tissue ratio, but still provide excellent bone-to-tissue uptake. The accumulation is usually equal and symmetrical in the normal patient.

Some of the specific indications for performing an isotopic bone survey are:

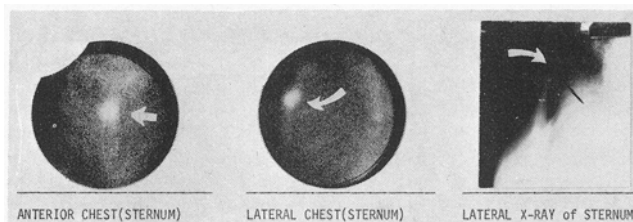


FIG. 4. Patient in study complained of pain in midchest area about sternum. Original radiographs were normal. Isotopic bone study revealed increased activity in area of complaint and subsequent x-rays confirmed diagnosis of fracture in sternum.

1. A general workup examination for patients with known or suspected malignancy.
2. Suspected bone lesions, not shown by radiographic studies, or to correlate lesions found on radiographic examinations.
3. Complaints of bone pain with unknown origin.
4. Followup examination after radiation therapy.
5. To possibly determine whether arthritis or osteomyelitis is present.
6. To determine the healing rate of skeletal fractures or any condition where there may be increased blood flow to the bone due to any pathological condition or disease.

When performing a bone scan there are several conditions that can cause increased uptake of the polyphosphate or diphosphonate. In addition to those already mentioned, there are some normal conditions that cause this increased accumulation. In the pediatric patient or patients who are still growing, there will be an increase in activity at the distal aspect of the long bones, such as the femurs, tibia-fibula, and humerus. This is seen when the epiphyseal centers are open and are still forming. Rarely is this occurrence noted in the adult whose epiphyses are closed; however, slight

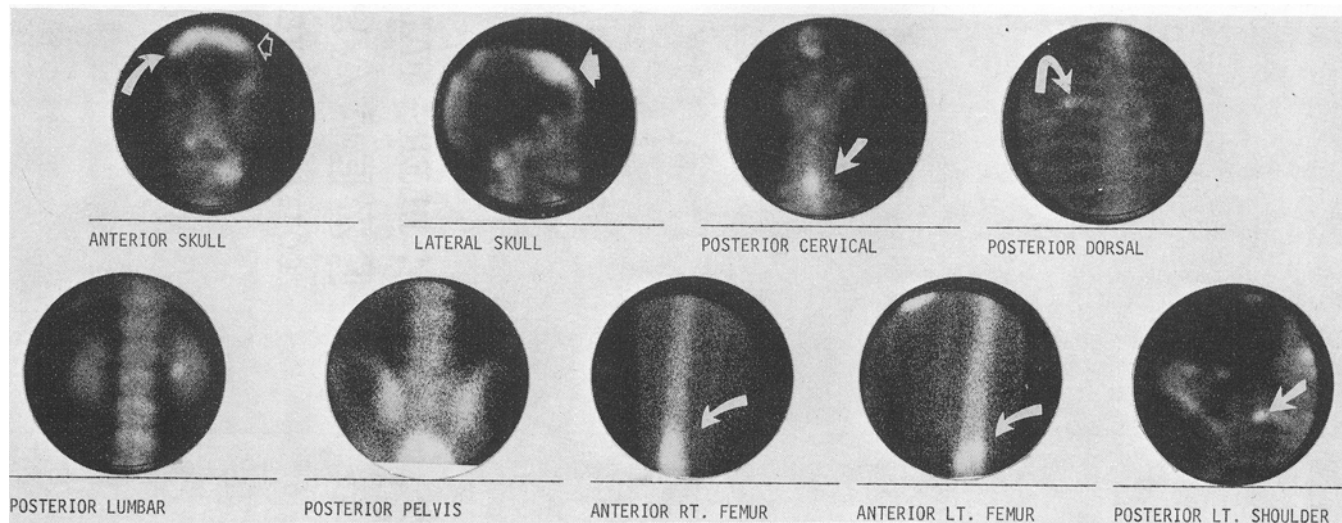


FIG. 3. Study of patient with previous history of prostatic carcinoma. Increased activity occurs in skull, ribs, cervical spine, and femurs.

FIG. 5. Patient had previous history of prostatic carcinoma. Isotopic bone study shows increased uptake in left sacroiliac area and in right scapula. This was shown to be metastatic disease.

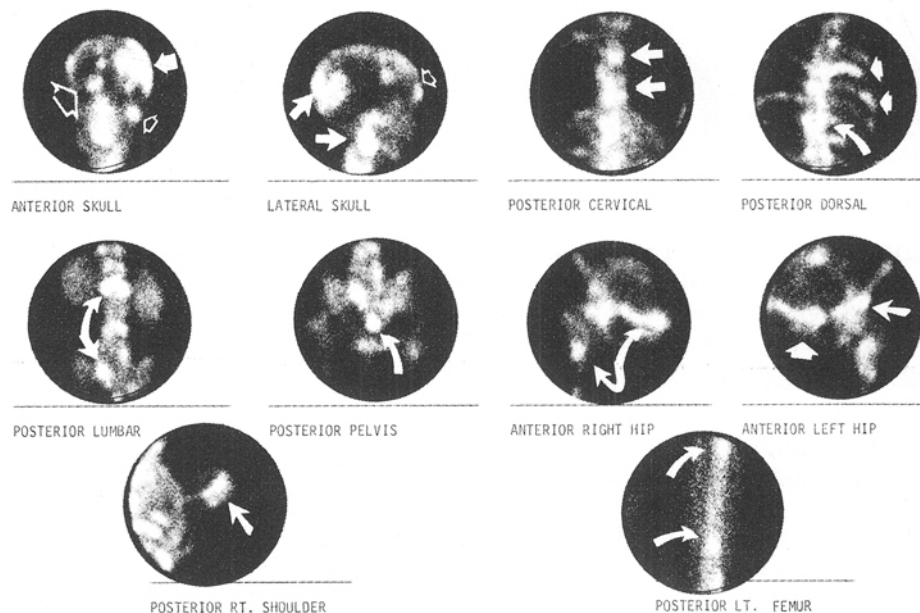
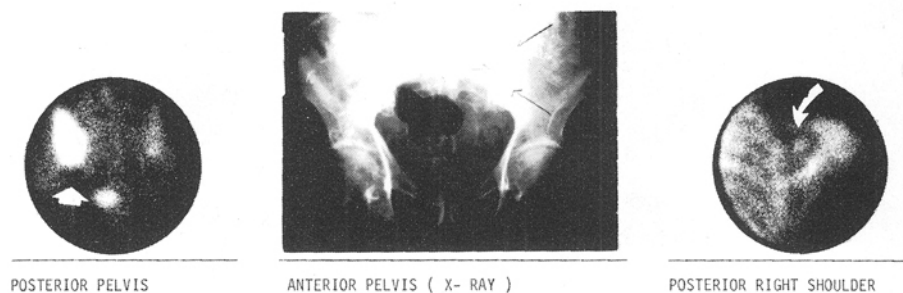


FIG. 6. Patient had breast carcinoma approximately 10 years previously. Examination shows extensive metastatic disease involving major portion of skeletal system.

increased uptake may persist in the long bones of the adult also.

In some instances there will be localized areas of decreased accumulation of the polyphosphate or diphosphonate such as occurs when the area has been subjected to localized radiation therapy.

Our Technique

The present techniques were developed in a relatively short period of time and have been found to generally provide excellent results. Our instrumentation is a Pho/Gamma III upgraded scintillation camera with a persistence scope and the high-resolution (low-energy) collimator. Our procedure is as follows:

1. No patient preparation necessary.
2. Dose: 15 mCi ^{99m}Tc -stannous polyphosphate or sodium diphosphonate injected intravenously.
3. Have the patient void his bladder several times over the next 4–6 hr and then return to the department.
4. Again have the patient void his bladder immediately before imaging. This has two purposes: (A) to decrease the radiation dose to the patient and (B) to remove un-

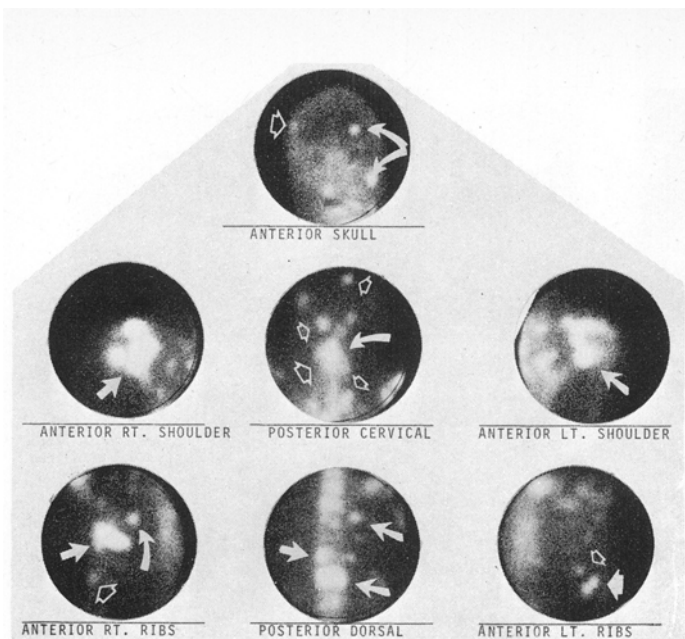
necessary activity from the pelvic area for better image contrast.

We routinely obtain the following views: anterior and posterior pelvis, anterior both hips, including proximal femurs, posterior lumbar spine, posterior dorsal spine to include the ribs, posterior cervical spine, anterior and lateral skull, and anterior (or) posterior both shoulders. Other areas, such as proximal and distal extremities are monitored with the persistence scope, and any area which may have increased activity is then imaged for a permanent record.

Our technical factors are:

1. Isotope energy 140 keV, plus peaking of the instrument.
2. 10–15% window to decrease background and provide enhancement of the image.
3. 300,000 counts per image (pelvis, hips, and spine).
4. 200,000 counts per image (skull, shoulders, and extremities except lower forearms and hands).

The polyphosphate or diphosphonate images obtained are shown in Figs. 1–7. The resolution has been increased considerably and most of the vertebral bodies, ribs, and various anatomical sites



usually seen only on radiographic examinations can be visualized. Some of the images demonstrate areas of disease that involve only a portion of a vertebra or rib and can be resolved easily. This type of information can be very valuable to a clinician when a course of treatment is being planned. This study can also be used repeatedly to follow the progression or regression of a disease.

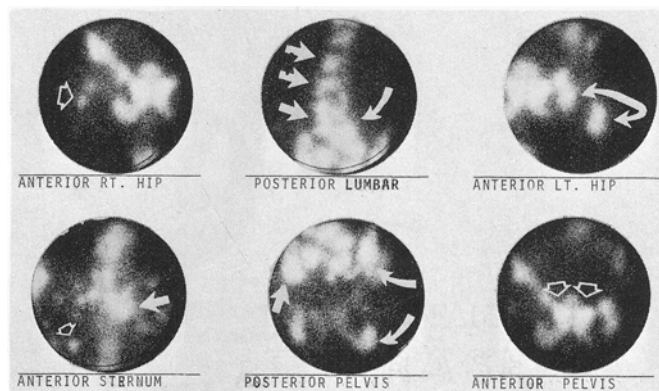


FIG 7. Man had history of prostatic carcinoma and was complaining of pain in right rib area. X-ray examination showed destructive process in right 4th rib anteriorly. Isotopic bone study shows increased activity in most of skeletal system. All of areas indicated are indicative of metastatic disease process.

Acknowledgment

I would like to thank my employer, Robert Mockett, for allowing me the time for the preparation of this paper. It involved several hours of time, not only on the job but away from it. Without his consideration and encouragement it would not have been possible.