BONE SCINTIGRAPHY WITH ^{47}Sc AND THE SCINTILLATION CAMERA

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The direct measurement of radioactivity in bone after the administration of a tracer has chiefly been done with ^{47}Ca and ^{85}Sr. ^{18}F has also been used recently (*1*). This isotope has numerous advantages: its half-life of 111 min is short, letting one record high counts while the radiation dose remains low. Moreover, the fluorine accumulates rapidly in the skeleton, and scintigrams can be made 1 hr after administration of the tracer. The isotope is a positron emitter, and when it is used with a positron camera, one obtains scintigraphic images rapidly and with great clarity (*2*).

Nevertheless, there are limitations to the use of ^{18}F. Because of its short period, one must be close to the site of production, and its price is quite high. We have therefore considered and tested a new procedure for bone scintigraphy. It consists of using the photoelectric peak of ^{47}Sc produced by the decay of ^{47}Ca. We report here the principle of the method, its advantages and applications.

MATERIALS AND METHODS

^{47}Ca is a difficult nuclide for scintigraphy because it emits beta and gamma rays with a half-life of 4.8 days. The energy of its photoelectric peak is 1.28 Mev. It decays into ^{47}Sc with a half-life of 3.43 days. ^{47}Sc yields stable titanium by emitting 166-kev gamma rays. The decay scheme is seen in Fig. 1.

The metabolism of the mixture of ^{47}Sc and ^{47}Ca injected intravenously has been studied by Taylor (*3*). This author has demonstrated that ^{47}Sc in solution follows an independent path and is fixed mostly in liver, kidneys, spleen and bones while the ^{47}Ca goes mostly to the bone. The reasons we chose ^{47}Sc to obtain bone images are the following:

1. ^{47}Sc produced from the decay of the ^{47}Ca fixed on the bone does not have the same metabolism as ^{47}Sc and remains fixed on the organic matrix of the bone.

2. The 166-kev energy of the scandium photoelectric peak fits very well with the optimum performance of a scintillation camera, which is very efficient in detecting gamma rays with energies between 100 and 400 kev.

3. The equilibrium of the ^{47}Ca and ^{47}Sc mixture is quickly reached. After 8 days in the skeleton the intensity of the photoelectric peak of ^{47}Sc is much higher than that of ^{47}Ca, giving far clearer images with higher contrast than the calcium does. The ratio between the two peaks $^{47}Ca/^{47}Sc$ is 2.5×10^{-2} (Fig. 2).

We carried out our first bone studies with ^{47}Sc on rats weighing about 200 gm and medium-size rabbits by intravenous injection of 20–50 μc of a ^{47}Ca–^{47}Sc mixture. In man, ^{47}Ca was injected intravenously in doses not exceeding 1 $\mu c/kg$ of body weight, doses lower than CIPR norms (100 μc). The bone scintigraphy was done with the Anger scintillation camera equipped with a collimator whose efficiency extended from 100–300 kev. The preliminary studies of the ^{47}Ca–^{47}Sc mixture was done using a sodium iodide crystal in conjunction with a photomultiplier. We have also been using lithium-drifted germanium junction, manufactured by SAIP (Société Applications Industrielles de la Physique), with the high resolving power of 5 kev for ^{60}Co. All the spectra were registered with a 400-channel selector.

RESULTS

The first scintigraphic image which was made 2 days after administration of the tracer, shows a highly active zone at the level of the liver and the kidneys (Fig. 3). The localization is due to the ^{47}Sc present in the solution at the time of injection when

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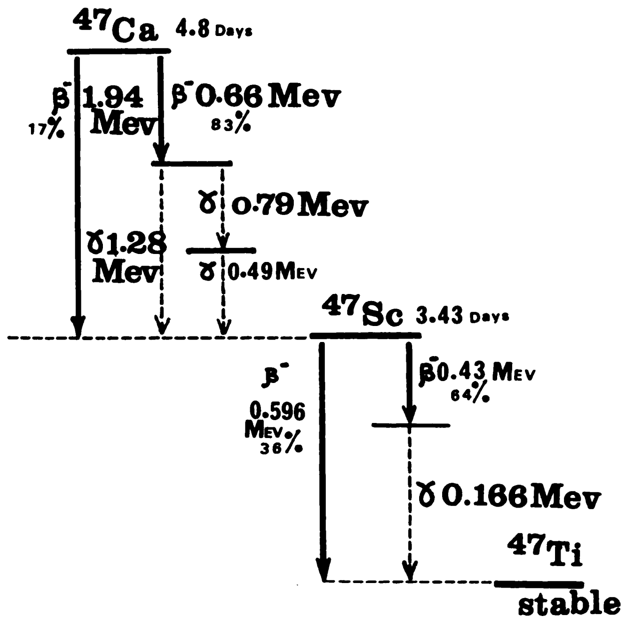

FIG. 1. Disintegrated scheme for ^{47}Ca.

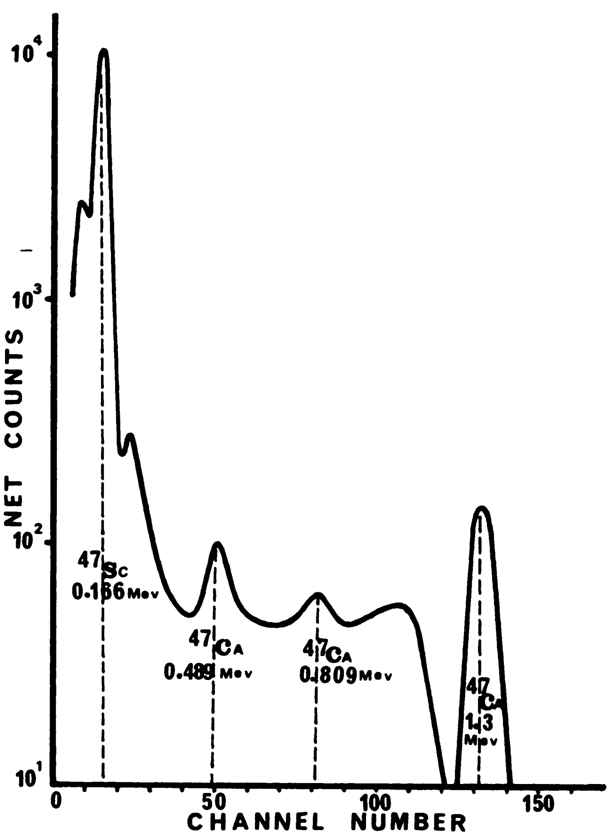

FIG. 2. Spectrum of ^{47}Ca–^{47}Sc mixture *in vivo* 8 days after injection into rats.

FIG. 3. Distribution of ^{47}Sc 2 days after injection of mixture of ^{47}Ca and ^{47}Sc in rat.

the ^{47}Ca–^{47}Sc mixture is practically at equilibrium; at this time the image of the skeleton begins to appear on the scintigram.

On the fourth, sixth and eighth days after the injection, the scintigraphic images show a progressive diminution of the active liver zone, whereas the radioactivity due to ^{47}Sc fixed on the skeleton is rising steeply. One can see a very intense fixation in the skull, the iliac region and the joints (Fig. 4). The scintigrams shown are of rats only because we have not so far obtained as good images of the whole animal with the larger rabbits.

DISCUSSION

We have compared several images of bone scintigraphy obtained with ^{47}Ca, ^{47}Sc and ^{85}Sr with the peak of our spectrometer at 490 kev for ^{47}Ca, 166 kev for ^{47}Sc and 514 kev for ^{85}Sr. The images ob-

FIG. 4. Distribution of ^{47}Sc in rat 8 days after injection of ^{47}Ca–^{47}Sc mixture.

tained with ^{47}Ca cannot be interpreted because the number of counts is very low and the background radiation is very high. For ^{85}Sr the resolving power of our camera remains low. The images obtained with ^{47}Sc are much better and show a high contrast (Fig. 4). One can see the lower limits of the rat with intense fixation zones at the joints.

A single study has been made with a visualization unit (Intertechnique) that lets one eliminate the background counts and thus improve the quality of the scintigrams. Unfortunately this short study with ^{85}Sr is the only one we were able to do while the unit was available, but we expect to improve the quality of our ^{47}Sc scintigrams equally in our later work.

In conclusion, it is interesting to note that ^{47}Sc for bone scintigraphy represents an excellent tracer for calcium because it lets one follow the progressive fixation of calcium in the bone since the physical character of ^{47}Sc is well suited to scintigraphic examinations. We feel this technique of bone scintigraphy with ^{47}Sc promises to be of great usefulness in man for studying many osteopathic disorders.

SUMMARY

After presenting some physical and metabolic characteristics of ^{47}Ca and ^{47}Sc, we propose a new technique for bone scintigraphy using the scintillation camera and ^{47}Sc as a tracer. The images obtained on rats and rabbits show a much better definition and contrast than those usually obtained with ^{47}Ca or ^{85}Sr.

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