

Bone Scintigraphy with ^{99m}Tc -labeled Phosphate Compounds and its Relationship to Bone Metabolism

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Scintigraphy of bone and joint with ^{99m}Tc -polyphosphate and ^{99m}Tc -pyrophosphate was performed for 134 cases with primary bone tumors, and other diseases of bone and joint. The results of scintigraphy were compared with the value of serum alkali-phosphatase, the findings of X-ray films and the results of bone kinetic study with ^{47}Ca .

^{99m}Tc -pyrophosphate was superior to ^{99m}Tc -polyphosphate as scanning agent in paperchromatographic studies, in faster excretion through kidney and in labeling efficiency.

The distribution of ^{99m}Tc -pyrophosphate and ^{32}P -pyrophosphate in rats were almost the same at 30 minutes 3 and 24 hours after intravenous administration, and showed maximum bone-to-blood ratio after 3 hours of injection.

Patients were given 10 mCi of ^{99m}Tc -pyrophosphate (or ^{99m}Tc -polyphosphate), and scintigraphy was performed by scintillation camera and whole-body scanner 3 hours later.

In 24 cases with primary bone tumors, osteosarcoma, osteoma, giant cell tumor, enchondroma and fibrous cortical defect showed positive results with exception of 2 of 5 cases with fibrous cortical defect whose scintigraphies were negative.

Any abnormal finding was not demonstrated on the X-ray films, in 13 of 20 cases with positive scintigraphy. In positive cases both on scintigrams and X-ray films, the values of alkaliphosphatase were high. Scintigraphy demonstrated definitely metastatic bone lesions in 4 cases with

normal alkali-phosphatase and without abnormal findings in X-ray films. In some cases under chemotherapy, hormone therapy and radiation therapy, the accumulation in the metastatic lesions were not observed. In 8 cases with multiple myeloma, the accumulations of ^{99m}Tc -pyrophosphate were rather decreased. The increased uptake was seen in the lesions of bone fracture, bone abscess, rheumatoid arthritis, osteoarthritis, tumoral calcinosis and thyroid cancer in which cases the calcification of thyroid was observed on X-ray film.

In 16 of 134 cases for whom ^{99m}Tc -pyrophosphate scintigraphies were undertaken, the kinetics of ^{47}Ca was determined. These cases included 3 normal subjects, patients with metastatic bone tumors, hyper- and hypoparathyroidism, osteoporosis, multiple myeloma, sarcoidosis and primary amyloidosis. Each patient was administered intravenously 5 to 10 μCi of ^{47}Ca , and radioactivities in whole-body, serum and urine were determined for a period of 2 weeks. The size of calcium pool, turnover rate and bone accretion rate were determined according to Heaney's single compartment model.

The average of calcium pool size, bone accretion rate and turnover rate in normal subjects was 4.57 g, 458 mg/day and 700 mg/day, respectively.

Acceleration of calcium metabolism was seen in cases with metastatic bone tumors with high level of alkali-phosphatase and with hyperparathyroidism. The decrease in calcium metabolism

was observed in cases with hypothyroidism and with multiple myeloma.

In comparison of the calcium kinetics with ^{99m}Tc -pyrophosphate scintigraphy, increased uptake of ^{99m}Tc -pyrophosphate in the lesion was seen in cases with accelerated calcium metabolism and decreased uptake was seen in cases with decreased calcium kinetics. The positive correlation between calcium metabolism and ^{99m}Tc -

pyrophosphate scintigraphy was indicated.

Our studies indicated that ^{99m}Tc -pyrophosphate appeared to be one of the best radiopharmaceuticals available for skeletal imaging. It is concluded that ^{99m}Tc -pyrophosphate scintigraphy reflects the bone metabolism of pyrophosphate and calcium, and that ^{99m}Tc -pyrophosphate accumulates in higher degree in malignant lesions than in benign lesions.

Basic and Clinical Studies of Bone Scanning with ^{99m}Tc -Pyrophosphate

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^{99m}Tc labeled tripolyphosphate was first reported as a bone scanning agent by Subramanian and coworkers in 1971 and several new ^{99m}Tc labeled phosphorus compounds such as polyphosphate, pyrophosphate and AEDPA, have been introduced since that time. The development of these new agents might led to widespread use of the bone scan. The purpose of this paper is to describe the results of our some clinical and basic studies with ^{99m}Tc -pyrophosphate.

Chemical quality was checked with paperchromatogram of in 85% methanol at immediate and 6 hours after preparation. Free ^{99m}Tc pertechnetate was not found even at after 6 hours.

Two and 4 hour distribution studies were done in rats for ^{99m}Tc -pyrophosphate and ^{99m}Tc -polyphosphate, respectively. The bone concentration of these two agents was similar, whereas the blood and muscle concentrations of polyphosphate were

higher than that of polyphosphate. The bone to blood and bone to muscle concentration ratio of the polyphosphate were somewhat higher than that of pyrophosphate, however, the better callus to normal bone concentration ratio which is the most important factor in diagnosis of bone scanning, was obtained with pyrophosphate than polyphosphate. There was no significant difference between 2 and 4 hour distribution of the two agents in rats.

Blood clearance and serial profile scans in patients were done for both pyrophosphate and polyphosphate. The clearance curves of the two agents could be resolved in two exponential compartments. The disappearance rate of pyrophosphate was much faster than that of polyphosphate. The serial profile scans showed very rapid excretion of the pyrophosphate from the body mainly through the kidneys. This could be