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 preperation. 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
due to hydrolysis of the pyrophosphate in the blood as well as in the kidneys. The total activity at 2 hours after injection was decreased to less than half of the initial counts, suggesting the possibility of the scanning in short time after injection.

Sequential bone images with $^{99m}$Tc-pyrophosphate were done to find optimal time for scanning. All images from the gamma camera were collected onto the cassette tape through the newly devised sytems and the change of the bone to soft-tissue ratio and lesion to normal bone ratio with time were studied. Bone to soft-tissue ratio increased as that of $^{85}$Sr bone scan. $^{99m}$Tc-pyrophosphate appears to be an excellent agent for bone scanning considering ideal physical characteristics of $^{99m}$Tc, rapidly with time till 2 hours after injection and then no significant increase was not found. Lesion to normal bone ratio gradually increased till one hour later and then stayed at the same level. The rapid increase of target to nontarget ratio could make possible to take very good skeletal images at any time beyond 2 hours after injection and there might not be much difference in image quality among these scans.

The exact mechanism of the localization of $^{99m}$Tc-pyrophosphate in the bone is not fully understood, however, the pathologic basis of $^{99m}$Tc-pyrophosphate bone scan seems to be same case of preparation, good chemical quality and rapid blood clearance.

Bone Tumor Imaging with $^{169}$Yb-citrate

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Tumor affinity of the Lanthanide series was first reported by Hisada et al. and one of the nuclides, $^{169}$Yb-citrate was proposed to be the most suitable tumor imaging agent. $^{169}$Yb-citrate also accumulated highly in some tissues other than tumors, i.e. bones, salivary glands and others, and when tumors were overlapped with skeletal system, the images sometimes became difficult to read to be positive tumor accumulation. So we intended to use $^{169}$Yb-citrate as a bone imaging agent rather than tumor imaging agent. Incidentally we had one autopsy case who died 19 days after $^{169}$Yb-citrate tumor scanning was done, and we confirmed that $^{169}$Yb-citrate accumulated chiefly in the bones (500–600 times of blood activity). From these results, we used $^{169}$Yb-citrate in detecting the location of malignant bone lesions on purpose of radiation therapy of these lesions.

Bone imaging was taken 2–5 days after injection of 150–200 $\mu$Ci of $^{169}$Yb-citrate intravenously.

Normal skeletal system, especially vertebral column, skull, pelvis, long bones and joints, was clearly delineated. The accumulation of $^{169}$Yb-citrate appeared to be slightly decreasing with age.

Forty-five bone images were obtained from 20 patients and nineteen lesions were detected by X-ray photo (X-p) and/or $^{169}$Yb-citrate (RI) imaging. These 19 lesions were confirmed by biopsy, operation, autopsy and/or clinical findings. Seventeen of these 19 lesions were detected by RI imaging (89.5%); of these 17, 15 (88.2%) revealed abnormal RI accumulation and 2 (11.8%)

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