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# TUMOR SCANNING WITH $^{169}$Yb-CITRATE

Kinichi Hisada, Norihisa Tonami, Tatsunosuke Hiraki, and Atsushi Ando

*Kanazawa University, Kanazawa, Japan*

***The results of tumor scanning with $^{169}$Yb are presented. Positive scans were obtained in 13 of 15 patients with primary lung and liver cancer or lymphosarcoma and various metastatic lesions of bone. The advantages and disadvantages of $^{169}$Yb as a tumor-scanning agent are discussed.***

Tumor scanning implies scintigraphy that can delineate focus as a positive image if a lesion is malignant. In certain specific areas such as the brain, positive delineation is not difficult. Certain tumors have the ability to accumulate specific substances; these include some types of thyroid cancer, chondrosarcoma, and malignant melanoma. The search for a single radiopharmaceutical that would be incorporated into all kinds of malignant tumors, regardless of anatomic location, has been carried out over several years by many groups [radiopharmaceuticals used on trial in clinical tumor scanning are listed elsewhere (*1*)], but these have not yet been perfected. Our previous report comparing clinical results with $^{67}$Ga-citrate, $^{197}$Hg-chlormerodrin, and $^{131}$I-human fibrinogen (*1*) shows that $^{67}$Ga-citrate gives the highest rate of detection of the lesion and the best image with relatively sharp margin, but it is not useful for differentiating a malignant tumor from a benign lesion because of its high false-positive rate.

The need for a compound with better tumor affinity than $^{67}$Ga-citrate has prompted us to use a radiolanthanide on the basis of promising results of animal experiments (*2*). For practical reasons, $^{169}$Yb-citrate was selected. The $^{169}$Yb is readily available and is a less expensive reactor-produced nuclide than is $^{167}$Tm which is not yet available in Japan and will be an expensive cyclotron-produced nuclide when it becomes available. Ytterbium-169 has a physical half-life of 32 days and primarily emits gamma rays (8–308 keV). The predominant energies of the gamma rays which are suitable for scintigraphy are 63 and 198 keV (*3*).

## SCINTIGRAPHY AND RESULTS

Ytterbium-169-citrate was prepared and supplied for human use by Dainabot Radioisotope Laboratory, Ltd., Tokyo. Its specific activity ranged from 370 to 448 mCi/mg at time of injection. All subjects were selected from among volunteers with a variety of known malignancies for the purpose of more precise localization of focus in radiation therapy.

One-half to 1 mCi of $^{169}$Yb-citrate (approximately 1 ml containing 2 mg of citric acid) was administered intravenously to each patient. Scintiphotos were obtained at intervals from 1 to 5 days following the administration. A Nuclear-Chicago Pho/Gamma III camera was used with a 1,000-hole parallel collimator for accumulating more than 50 K counts. Window width was $\pm 15\%$ and centered in one of the photopeaks of $^{169}$Yb (198 keV). In our 15 cases, no side-effect has been observed. Figure 1 shows a case with pulmonary cancer. P-A and lateral chest x-ray films showed a primary focus at a right posterior basal segment and metastasis to the left fourth rib. The scintiphoto at 72 hr after injection very distinctly visualized the primary focus as well as a metastatic bony lesion and also disclosed a hilar metastasis which was not found on x-ray. In addition to this information, the spinal column was delineated clearly which was useful as an anatomical landmark. Figure 2 shows another proven case with liver cirrhosis accompanied by a hepatoma. A $^{198}$Au-colloid scan showed a large space-occupying lesion in the lower portion of the right lobe of the liver and marked visualization of the spleen. Both scinti-

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For reprints contact: Kinichi Hisada, Dept. of Nuclear Medicine, School of Medicine, Kanazawa University, 13-1 Takara-machi, Kanazawa-shi, Japan.

photos, obtained 48 hr after injection of $^{67}$Ga-citrate and $^{169}$Yb-citrate, disclosed a distinct accumulation of tracer into the hepatoma. The $^{169}$Yb tumor image was clearer than the $^{167}$Ga tumor image mainly because of a lower background in soft tissue. The accumulation of $^{169}$Yb in the lumbar spine did not obscure the tumor image in this case. In 13 of 15 cases, the tumors were positively delineated. These included five cases with primary lung cancer, two with primary liver cancer, two metastatic liver cancers, one lymphosarcoma of the neck, one cancer of the oral cavity, one metastatic cancer of the skull from Ewing's sarcoma of lower leg, and one with metastatic cancer of the pelvis and sternum from nasopharyngeal cancer. Scintigraphic delineation of a tumor could not be obtained in two cases, the first of esophageal cancer in the neck and the second of mediastinal tumor. In these two cases the radioactivity in the spinal column and sternum might have obscured the lesions.

## DISCUSSIONS AND CONCLUSIONS

Although the mechanism of isotope localization within the tumor is unknown at this time, it is quite definite that $^{169}$Yb-citrate can be used for tumor scanning. To discuss precisely superiority or inferiority of $^{169}$Yb-citrate to $^{67}$Ga-citrate, direct comparison will be needed in the same group of patients. However, the main peak of gamma rays of $^{169}$Yb (178, 198 keV) is very close to that of $^{67}$Ga (184 keV), and it is not easy to distinguish $^{67}$Ga and $^{169}$Yb by a conventional scintillation camera or scanner so that one must wait to administer $^{169}$Yb-citrate to the patient until $^{67}$Ga given previously will decay. The result of this direct comparison will be reported in a future communication.

The advantages and disadvantages of $^{169}$Yb-citrate tumor scintigraphy are as follows.

**Advantages.**

1. Since $^{169}$Yb has a relatively long shelf-life (physical half-life is 32 days), $^{169}$Yb can be available any time when tumor scintigraphy is required.

2. $^{169}$Yb is a reactor-produced nuclide and much cheaper than $^{67}$Ga which is a cyclotron-produced nuclide.

3. The main peak of gamma rays of $^{169}$Yb is 198 keV and suitable for scintigraphy.

4. Body background in soft tissues is extremely low, especially 3–5 days after injection, and tumor images are obtained very clearly.

5. Distinct visualization of the skeleton is helpful in localizing the tumor to the anatomical landmark.

**Disadvantages.**

1. The skeletal image might obscure the tumor image when superimposed. For instance, if the lesion in the mediastinum is hidden by the spinal column and sternum, oblique or lateral views are recommended.

2. Exposure to the patient is relatively high. Clinical data are available of effective half-life of $^{169}$Yb-citrate on only one patient because tumor scanning is rarely performed without being preceded by other nuclide organ scanning at the present time. The effective half-life was 11.8 hr in the fast phase (40% of a dose administered) and 26.9 days in the slow phase (60%). Dose calculation was made according to the MIRD formula (all physical data of $^{169}$Yb were obtained from E. M. Smith). A 0.5-mCi dose of $^{169}$Yb-citrate in a patient weighing 50 kg delivered 1.74 rads to the whole body and 5.77 rads to the bone. Radiation doses were comparable to those of other agents currently in use, $^{203}$Hg-chlormerodrin or $^{75}$Se-selenomethionine.


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