An Improved Whole Body Bone Scanning Technique

P.J. Ell, M.D., A.T. Elliott, Ph.D., B. Sanyal, M.D., F. McSweeney, DRC., and J. Lovell, DNM
Department of Nuclear Medicine, The Middlesex Hospital Medical School, London, England

Abstract. Whole body bone scanning with $^{99m}$Tc-labelled phosphates is now well established in routine clinical practice. It is the most sensitive indicator of early pathology in the skeleton and it remains a non-invasive, safe, and easy procedure. It has passed the test of time and it is unlikely to be replaced even by the most modern computerised axial tomography techniques. The unique ability to display a high resolution image of the entire skeleton in 20 minutes is largely responsible for its wide clinical acceptance. The main disadvantage of the technique—the inconvenient waste of time, usually three hours, between tracer injection and actual image procedure—can now be overcome by utilising superior radio-pharmaceuticals and data processing techniques.

A new $^{99m}$Tc-Imidodiphosphonate was utilised in 100 patients presenting for whole body scanning. Good quality reproducible images were obtained one hour after intravenous administration of the radio-pharmaceutical. Utilising a digital subtraction technique, this new bone scanning agent gave clinical information identical to that obtained with standard three-hour scans. $^{99m}$Tc-Imimidophosphonate is now our routine home-made bone seeking radio-pharmaceutical, produced at a cost of 50 pence (approximately $ U.S. 1) per whole body scan. The relative rapidity of the procedure has permitted a significant increase in the number of investigations performed.

Key words: Whole body bone scanning - $^{99m}$Tc-Imimidophosphonate ($^{99m}$Tc-IDP) - Radio-pharmaceutical - $^{99m}$Tc-labelled phosphates - Digital subtraction - Cleon scanner

The success of whole body bone scanning (a non-invasive investigation, with acceptable radiation dose and high sensitivity to early changes in bone) has increased the demand for this nuclear medicine imaging technique. In 1975, 721, in 1976, 776, and in 1977, 1088 patients were referred to our department for whole body bone scanning. This investigation has been of value in solving a number of clinical problems, amongst which staging of carcinomas of the breast, the prostate, and the bronchus, for assessment of treatment and management, occupy a prominent position. The sensitivity of the technique is clearly superior to the standard diagnostic procedures, such as classical radiographic imaging and serum enzyme measurements [2, 10, 13, 15]. Serial investigations can be performed to monitor the change of benign or malignant bone disease with time or treatment [1, 9, 12]. Quantitative rather than qualitative information is readily available, with data processing equipment allowing for the establishment of normal ranges and normal to disease uptake ratios in specific areas of the skeleton [5, 11, 19].

Advances in this field have not ceased since the initial discovery by Subramanian et al. of the excellent properties of $^{99m}$Tc-labelled phosphates as bone seeking radio-pharmaceuticals [16]. Better instruments are now available for faster and more reliable whole body imaging, better display systems have been introduced, superceding the excessive costs and limited range characteristics of polaroid film, and more stable and reproducible radio-pharmaceutical preparations have become available. Modern and efficient gamma cameras now can record fine detail and structure, permitting rapid whole body screening for the detection of multiple skeletal metastases [7].

One major residual problem is the excessive waiting time required between administration of the radio-pharmaceutical and the actual imaging time, usually up to three hours. This prolonged interval severely limits the number of patients investigated daily, since the actual scanning often is performed necessarily in the afternoon period. Recently a new $^{99m}$Tc-labelled
phosphate has been reported in the literature [18]. Its high uptake by the skeleton, coupled to reasonably fast blood clearance characteristics, appears to provide it with optimal qualities as a bone-scanning radio-pharmaceutical.

This investigation was undertaken to evaluate this new agent in the context of whole body scanning and to ascertain to what extent early imaging is possible, permitting reduction of the standard three-hour time delay between tracer administration and patient imaging.

Materials and Methods

One hundred patients referred for whole body bone scanning for a variety of conditions (mainly early diagnosis of metastatic involvement, from carcinoma of the breast, prostate, or bronchus) were investigated using 15 mCi of $^{99m}$Tc-Imidodiphosphonate ($^{99m}$Tc-IDP). The labelling technique is identical to the procedure described by Brody et al. in 1976 [4]. Kits are made up sterile and pyrogen-free and ready for a single-step labelling procedure and intravenous injection. Each kit contains the equivalent of 2.2 mgs imidodiphosphoric acid and 0.26 mgs of tin. At room temperature, 15 mCi of $^{99m}$Tc as pertechnetate is added to an individual vial, the average labelling efficiency being above 85%. Whole body imaging was performed one hour after intravenous administration of the $^{99m}$Tc-IDP to hydrated patients. In approximately one-third of the series imaging was repeated at the standard time of three hours.

All whole body scans were performed on a new whole body imager [8] which basically consists of two detectors, each comprising a $10 \times 1$ array of sodium iodide crystals with a large area (700 cm$^2$ per head) able to scan a surface of 193 x 68 cm producing anterior and posterior views simultaneously (Cleon Scanner). The information is formatted into a 512 x 160 point matrix for each view and stored on a floppy disc. 10" x 8" roentgen or polaroid film output is available. Whole body bone scans (both anterior and posterior projections) with excellent resolution are obtained in less than 25 minutes.

A background subtraction facility is provided, by which a selectable number of counts in the range 0-15 may be subtracted from each cell of the image matrices prior to display. A bone scan image may be regarded as being composed of two elements, counts arising from the radio-pharmaceutical taken up by the skeleton and those arising from the radio-activity circulating in the blood. The latter component gives rise to a ‘background’ soft tissue image which is superimposed upon the skeletal image, thus reducing the target (bone) to non-target contrast of the display.

When the intensity of the ‘background’ image is reduced, conventionally by waiting for a sufficiently long time for the kidneys to clear the radio-pharmaceutical from the blood, the target to non-target ratio, and hence the display contrast, is increased. This approach suggested the possibility of utilising the background subtraction facility of the imager.

In order to demonstrate the effect of background subtraction, and to obtain a measure of the performance to be expected from the images, a phantom primarily designed to test gamma camera performance was employed. The phantom, constructed from perspex and shown in Figure 1, consists of a $6 \times 10$ array of square pegs. The pegs in each row are of the same length and breadth but of different heights, the heights being selected to give contrasts

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Fig. 1. The perspex phantom utilized in this investigation. Description as in the main text