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Quantification of radionuclide uptake levels for primary bone tumors

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ABSTRACT

The purpose of the study is to quantify the level of uptake of administered radionuclide in primary bone tumors for patients undergoing bone scintigraphy. Retrospective study on 48 patient's scintigrams to quantify the uptake levels of administered radiopharmaceuticals was performed in a nuclear medicine unit in Ghana. Patients were administered with activity ranging between 0.555 and 1.110 MBq (15–30 mCi), and scanned on Siemens e.cam SPECT system. Analyses on scintigrams were performed with Image J software by drawing regions of interest (ROIs) over identified hot spots (pathologic sites). Nine skeletal parts namely cranium, neck, shoulder, sacrum, sternum, vertebra, femur, ribcage, and knee were considered in the study, which involved 96 identified primary tumors. Radionuclide uptakes were quantified in terms of the estimated counts of activity per patient for identified tumor sites. Average normalized counts of activity (nGMC) per patient ranged from 5.2759 ± 0.6590 cts/mm^2/MBq in the case of cranium tumors to 72.7569 ± 17.8786 cts/mm^2/MBq in the case of ribcage tumors. The differences in uptake levels could be attributed to different mechanisms of Tc-99m MDP uptake in different types of bones, which is directly related to blood flow and degree of osteoblastic activity. The overall normalized count of activity for the 96 identified tumors was estimated to be 23.0350 ± 19.5424 cts/mm^2/MBq. The study revealed highest uptake of activity in ribcage and least uptake in cranium. Quantification of radionuclide uptakes in tumors is important and recommended in assessing patient's response to therapy, doses to critical organs and in diagnosing tumors.

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1. Introduction

Bone scintigraphy procedure in nuclear medicine uses Tc-99m Methylene Diphosphonate (MDP) for diagnostic evaluation of patients with metastatic and non metastatic conditions of the bones (Habib, 2006; O'Reilly, Shields, & Testa, 2000). It is a valuable tool for early diagnosis, localization and quantification of muscular involvement in bone diseases, and also useful in monitoring therapeutic responses (Bar-Sever, Mukamel, Harel, & Hardoff, 2000; Lim, Sohn, & Park, 2000; Otsuka et al., 1988). Bone scintigraphy is highly sensitive, and its greatest strength lies in the ability to provide early physiologic information about the involved bone and to evaluate multiple areas in a single, relatively rapid examination. Diagnostic specificity and accuracy for many bone scintigraphic examinations have improved due to improvement in imaging techniques such as Single Photon Emission Computed Tomography (SPECT) and three-phase scanning, coupled with quantitative assessments of scintigrams (Bombardieri et al., 2003; Lurye, Castronovo, & Potsaid, 1977; McNail, 1978).

Primary bone tumors are tumors with their origin in the cells of the bone itself, and early diagnosis of this condition is best achieved with scintigraphy among other imaging modalities. Bone scintigraphy depends ultimately on the ability of a nuclear medicine physician to accurately interpret images obtained after scanning patients. It is at this stage that the subjectivity of the physician impacts on the outcome of the patient's diagnosis. Hence, it is desirous to adopt measures of decreasing as much as possible the physician's subjectivity in the interpretation of the scan.

Single Photon Emission Computed Tomography system enhances the contrast resolution of bone scans by screening out overlying or underlying tissues. This results in improved detection and localization of small abnormalities, especially in the spine, pelvis, and knees. In some cases, increased activity not seen or only vaguely detected on planar views can be definitively demonstrated with SPECT. The images are sometimes reprojected into a three-dimensional one which is viewed in a dynamic rotating format on computer monitor, facilitating the demonstration of pertinent findings to the referring physician.

Many authors (Hasford et al., 2010; Jones, Francis, & Davis, 1978; Ludwig, Kumpan, & Sinzinger, 1982; Mettler & Guiberteau, 1998; Subramanian, McAfee, Blojr, KalIfeIz, & Thomas, 1975; Thrall, Geslien, Corcoron, & Johnson, 1975) have over the years performed studies on radionuclide bone scintigraphy in nuclear medicine, qualitatively. However, quantitative approach has proved to have added advantage due to its ability to quantify radionuclide uptake levels in various parts of the body. The application of credible quantitative assessment tools such as Image J to analyze the uptakes would aid in accurate interpretation of bone scintigrams by developing mechanisms that rely not so much on how physicians see a bone scan, but on quantitative data provided by the software (Collins, 2007).

In addition to being readily available for no cost on the internet, Image J is supported by a wide range of constantly evolving user-created functionalities to address a remarkable range of applications, complementing commercial software that typically comes with imaging instruments. The software operates on a range of platforms like Windows, Mac, and Linux for image processing.

The aim of this study is to quantify and assess radionuclide uptake levels for primary bone tumors in various parts of the skeletal system. The uptake levels are characterized by the counts of activity measured from specific regions of interest in the patient scintigrams.

2. Methodology

2.1. *Acquisition of bone scintigrams*

Patients undergoing bone scans in a nuclear medicine unit in Ghana were intravenously administered with Tc-99m MDP soon after preparation of radiopharmaceutical (Tc-99m MDP). Administered activity typically ranged from 0.555 to 1.110 MBq (15–30 mCi) depending on a patient's weight and age. To aid in rapid clearance of radioisotope from the bladder, patients were adviced to drink four to six glasses of water between time of injection and time of image acquisition. Whole-body bone scintigrams were acquired with a Siemens e.cam SPECT system which was equipped with a Low Energy All Purpose (LEAP) collimator. The process of image acquisition is shown in Fig. 1. Images were acquired with a matrix size of 256×1024 and displayed in grayscale on the system's computer unit for a resident nuclear medicine physician's interpretation and diagnosis.

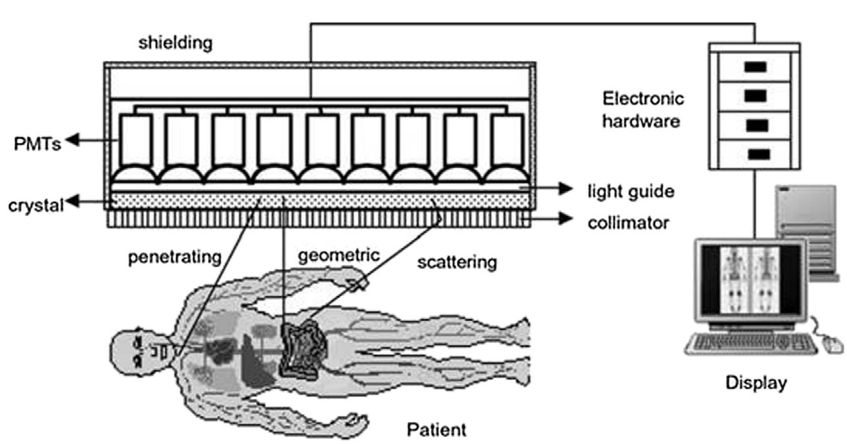

Fig. 1 – System of image acquisition using e.cam SPECT system.