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Development of a small field of view scindmmmography camera: measurements and simulations.

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ABSTRACT

We report on studies of a small field of view scintimammography camera based on a position sensitive PMT and a crystal scintillator array. A 5-inch R3292 Hamamatsu PMT was coupled to a variety of scintillators, including pixelized NaI(TI), Csi (Na) and YAP. Laboratory and phantom studies were performed to compare performances of the above scintillator sensors with special emphasis on spatial resolution and scatter rejection. The results of Monte Carlo simulations for different pixel sizes are also presented.

Keywords gamma-ray, imaging, mammography, scintimarnmography, small field of view gamma camera, application specific gamma imager, breast cancer detection, YAP, CsI(Na), NaI(TI), pixelized

1. INTRODUCTION

Routine screening mammograms are recommended for women over 40 to 50 by the American Cancer Association to identify breast cancer patients as early as possible as the patient's prognosis is better the earlier the cancer is recognized and treated. This approach leads to many cases of suspicious lesions found on screening mammograms. Core needle biopsies are often warranted, but are performed on benign lesions in about 80% of the cases. They are invasive, painful, and likely to leave scar tissue in the breast that makes future mammograms harder to read. An alternative procedure is sought to distinguish malignant from benign lesions. There is much interest in nuclear imaging of the breast as nuclear medicine is successfully used in other areas of oncology and it can offer high sensitivity and specificity for breast lesions.[1,2,3] Scintimammography might be a valuable alternative to current methods of patient diagnosis if it can be made reliable and cost effective. Current gamma cameras are not optimized for lesion detection in dm breast and the development of an application specific gamma camera might make a crucial difference in the reliability of breast scans.

After ten minutes post injection of 20 mCi of ^{99m}Tc, most of the activity is concentrated in organs like the heart (0.24 mCi) and the liver (3.4 mCi), for example. While a malignant tumor might be expected to take up 10 times more radiation per cc than the surrounding breast tissue, the total uptake in the breast might only be 0.05 mCi. A 2cc hot spot, for example, due to a malignant lesion, might be several centimeters deep in the breast and close in geometry to much stronger sources. Positioning the detector close to the breast without including the patient's organs or torso in the field of view, and rejecting scatter from the data, are crucial steps in reliable cancer detection in the breast.[4]

We present our results from imaging experiments with several small phantoms as well as with a fully tissue equivalent anthropomorphic human torso phantom in a clinical environment. Permitting organs and body cavities to be filled with appropriate tracer concentrations the phantom realistically replicates the effect of gamma attenuation and scattering. We compared the performance of cameras based on three different crystal scintillators and evaluated different geometries for phantom imaging as well as the effects of lead apron shielding.

2. EXPERIMENTAL DETAILS

2.1 Apparatus and Data Acquisition System

Our detector is based on a 5 inch Hamamatsu R3292 position sensitive photomulitipliertube (PSPMT), an array of small pixels of a scintillator, and a collimator. See Figure I for a schematic. We obtained data with YAP, NaI(TI) and