OPTIMIZATION OF A PORTABLE GAMMA IMAGING SYSTEM DEDICATED TO ABSORBED RADIATION DOSE CONTROL IN TARGETED RADIONUCLIDE THERAPY

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Targeted radionuclide therapy is one of the most used modalities in the treatment of benign thyroid diseases. The large heterogeneity of absorbed doses and effects observed in patients, both in terms of toxicity and response, demonstrate the needs of individualized dosimetry for optimizing this therapy. In clinical practice, patient-specific dosimetry relies on the quantification of radiopharmaceutical uptake, as a function of time, which is obtained both from pre-therapy tracer studies and measurements made with a counting probe after injection of the radionuclide, but the best way to reach real dose quantification would be to perform imaging during treatment. The aim of the project is to strengthen the control of the dose delivered to thyroid developing a novel mobile gamma imaging device dedicated to semi-quantitative measurements of the bio-distribution and kinetics of the radio-tracer. Unlike conventional gamma cameras, the camera will be optimized to meet the specific needs of imaging with high energy and high activity radionuclides and its ergonomics will be suited for using it at patient's bedside in order to achieve high temporal sampling. The final purpose is to develop a 10x10 cm^2 field of view camera that consists of a parallel-hole high-energy tungsten collimator, coupled to a continuous inorganic scintillator, readout by arrays of SiPMs. We report here the simulation study aiming to optimize the detection head design of the camera with the GATE simulation platform. Several hexagonal shaped collimator designs were investigated with a ^{131}I line source in terms of Spatial Resolution (SR), Sensitivity (S) and Septal Penetration (SP). Accurate characterization of events crossing the collimator, using GATE actor tool, allows detailed investigations of its intrinsic properties, such as useful S (detected events in a 2σ ROI centered in the emission points) and effective SP (septal penetration-events outside the 2σ ROI), which cannot be estimated from conventional analytical models. Five configurations with an effective SP of 10% and a SR ranging from 1 to 5 mm was chosen based on simulation results and interpolation methods (fig.1). The imaging properties of these collimators were then investigated in a more realistic clinical context simulating the thyroid treatment (XCAT voxelized phantoms). Both background and hyperthyroidism activities distributions, characterized by hot nodules spread out with different diameters, are simulated at 24 h after the ingestion of ^{131}I according to biokinetics models. The design of the complete camera is also fully modeled and its intrinsic performances, spatial and energy resolutions, are obtained from experimental measurements with different scintillator-photodetector assemblies. Simulated images are corrected according to the MIRD 16 protocol and performances of the different detector configurations are compared in terms of contrast and activity recovery coefficient in thyroid nodules (fig. 2).

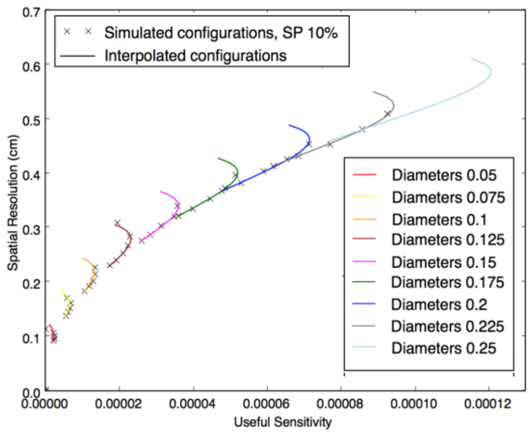

fig.1: Usefull sensitivity as a function of the SR for collimator designs with an effective SP of 10%. The 5 configurations are chosen from the interpolation's curves

fig.2: Image of multiple thyroid nodules (12mm cold nodule and 12 mm/6 mm hot nodules), obtained with one of the chosen collimator (2 mm SR).