PhD Thesis Title: Application development for personalized dosimetry in pediatric examinations of Nuclear Medicine based on Monte Carlo simulations and the use of computational models

Author: Theodora Kostou
Email: theokost@upatras.gr
Institution: Medical Physics Laboratory, School of Health Sciences, University of Patras, Greece
Supervisors: George C. Kagadis, Professor, Department of Medical Physics, University of Patras, Greece
Graduation Date: July 25, 2019
Available Online: Available upon request from author

ABSTRACT:

This thesis aims to develop and certify innovative personalized dosimetry tools in pediatric nuclear medicine examinations (Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET), and multimodal SPECT/PET/Computed Tomography (CT)). Furthermore, it aims at optimizing therapeutic approaches, using Monte Carlo simulations with high resolution computational anthropomorphic phantoms, enriched with individual patient characteristics.

As the use of radiopharmaceuticals in imaging and therapy increases, it becomes important to achieve a higher level of accuracy in internal dosimetry on small animal studies as well. We validated our tools and methods by performing dosimetric calculations to create a small-animal database for nuclear medicine. Commonly used radiopharmaceuticals were studied to define the absorbed dose rates for several organs of interest in preclinical studies. We also extended the dosimetric calculations for common PET and SPECT exams to specify the impact on the absorbed dose calculation by the size of each different organ.

Furthermore, we studied the clinical applications in pediatric nuclear medicine. We used the formality of the “Specific Absorbed Dose Rates” (SADRs) for each organ, according to the specified biodistribution of each radiopharmaceutical to reach better accuracies in defining organ doses.

As the CT scanners have now been integrated into multi-modality PET/CT and SPECT/CT devices, their impact on radiation exposure, especially in pediatric applications has dramatically increased. In the direction to quantify this impact, dosimetry simulations and calculations were performed, including updated pediatric protocols of head, chest and abdomen/pelvis exams. When an anatomical difference is observed, the difference in the absorbed dose per organ for each body type is reported.

To sum up, the aims of this thesis were: a) to create a dosimetry database that contains simulated pediatric data produced by Nuclear Medicine and CT acquisitions, and b) to

match any new pediatric patient to the “best” fitted anatomical model of the database according to the characteristics of its internal organs. This method results to a more accurate organ dose assessment.

References to author publications that relate specifically to the dissertation:

1. **T. Kostou**, P. Papadimitroulas, G. Loudos, G.C. Kagadis, “A preclinical simulated dataset of S-values and investigation of the impact of rescaled organ masses using the MOBY phantom”, Phys. Med. Biol. 2016;61(6):2333–2355.
2. P. Papadimitroulas, W.D. Erwin, V. Iliadou, **T. Kostou**, G. Loudos, G. C. Kagadis, “A personalized, Monte Carlo based method for internal dosimetric evaluation of radiopharmaceuticals in children”, Medical Physics 2018;45(8):3939-3949.
3. P. Papadimitroulas, **T. Kostou**, K. Chatzipapas, D. Visvikis, K.A. Mountris, V. Jaouen, K. Katsanos, A. Diamantopoulos, D. Apostolopoulos, A. Balomenos, Y. Kopsinis, G. Loudos, C. Alexakos, D. Karnabatidis, and G.C. Kagadis, “A Review on Personalized Pediatric Dosimetry Applications Using Advanced Computational Tools”, IEEE Transactions on Radiation and Plasma Medical Sciences, 2019;3(6): 607-620.
4. **T. Kostou**, P. Papadimitroulas, P. Papaconstadopoulos, D. Slobodan, J. Seuntjens, G.C. Kagadis, “Size-Specific Dose Estimations for pediatric chest, abdomen/pelvis and head CT scans with the use of GATE”, Physica Medica, 2019;65:181–190.