PhD. Dosimetry for ^{177}Lu treatments in internal radiotherapy based on imaging and Monte Carlo simulations

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This work is a collaboration between researchers from CREATIS lab and the nuclear medicine department of the Léon Bérard cancer center (Lyon, France).

Context. In nuclear medicine during last ten years, cancer treatment by Molecular Radionuclide Therapy (MRT) has been growing rapidly. As an example, peptide receptor radionuclide therapy (PRRT) has been shown to be an alternative treatment for neuroendocrine tumors (NETs) when surgery is not indicated [1]. MRT consists in intravenous administration of a molecular vector labeled with a radionuclide. The vector's goal is to accumulate the compound in target organs and β or α-emitting radionuclide provides cytotoxic effects. Lutetium 177 is one of the most used radionuclides. In addition to β particles, it also emits γ rays that allows to quantify the radionuclide concentration in the tumors and healthy organs with SPECT/CT images acquisitions repeated at different point-times after treatment injection.

Patient-personalize dosimetry [2], [3] is a key notion that allows to optimizes tumor control by administering the highest possible activity in target volume while limiting complications irradiation to organs at risk. The principle is to estimate the biodistribution and the pharmacokinetic of the activity inside the patient from SPECT/CT images. This image-based estimation is however impaired by numerous effects (attenuation, scatter, breathing motion…) that must be corrected or accounted for [4]–[6].

Monte Carlo simulation of SPECT imaging systems consists in building a virtual model of the imaging process in the most accurate way possible [7], [8]. It allows to optimize the acquisition parameters, to calibrate the images and to estimate the dose distribution.

Objectives

1 - First, propose and implement a complete dosimetry workflow for ^{177}Lu-based treatments both for clinical and pre-clinical studies. Clinical studies are performed at LUMEN nuclear medicine department (Léon Bérard cancer center, Lyon) and involve Lutathera therapy and other related ^{177}Lu-based treatments. Pre-clinical studies are performed at ImThernat platform and are related with new Netrin-based treatments developed at the CLB.

2 - Second, in order to acquire a better understanding on the physical processes involved during both imaging and therapy, we aim to continue the development of Monte Carlo simulations for the different SPECT imaging systems available. At the time of the PhD, three systems will be available: an analog conventional Discovery NM CT 670 (GE Healthcare), a CZT-based digital VERITON-CT (Spectrum Dynamics Medical) and a NanoSPECT/CT multipinhole camera (Mediso BioScan). The goal will be to develop and validate Monte Carlo models against experimental data. In particular, it will allow to optimize the performances of the digital solid-state VERITON-CT, for ^{177}Lu quantification in the context of personalized dosimetry. A

VERITON Monte Carlo model, using the GATE platform, will be developed to acquire a better understanding on the physical processes involved in the ^{177}Lu quantification. A series of experimental measurements will have to be performed to validate the VERITON Monte Carlo model.

3 – Third, according to the timeframe and the candidate interest, a deep learning approach could be initiated with the long-term goal towards predicting response to ^{177}Lu treatment. The first steps of this work will be to identify the needed learning data and to investigate appropriate machine learning technique.

Environment. The student will work in a multidisciplinary team composed of nuclear physicians, medical physicists, radiopharmacists, researchers and computer scientists of CREATIS laboratory and Leon-Bérard Cancer Center. He/she will also exchange with the teams of associated hospitals. This study will give the student the opportunity to work in both imaging and dosimetry in the field of nuclear medicine.

Details.

- Expected skills: medical physics, computer sciences, image processing
- English and French
- Funded by the Lyrican project: https://www.cancer-lyrican.fr
- Expected start: September or October 2020.
- Location: Lyon, Léon Bérard Cancer Center
- Send CV to: David.Sarrut@creatis.insa-lyon.fr and jeannoel.badel@lyon.unicancer.fr

References

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