Investigating parametric digital PET imaging in theranostic. Application to personalized ^{177}Lu-based cancer treatments

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This work is a collaboration between CREATIS lab, LUMEN[1] and Siemens Healthineers. The PhD will be located in Lyon, France. It will be funded by a CIFRE contract (see ANRT). The goal is to investigate the interest of parametric PET images in predicting patient personalized dosimetry of ^{177}Lu-based cancer treatments usually obtained from multiple SPECT images in order to improve and simplify the theranostic workflow.

Medical context

Personalized ^{177}Lu-based therapy is rapidly expanding in the nuclear medicine field. It consists in intravenous administration of a molecular vector radiolabeled with ^{177}Lu. The molecular vector allows the absorption of β-emitting ^{177}Lu in the target organs, which leads to cytotoxic effects. One typical example is the treatment of neuroendocrine tumors when surgery is not indicated [1]. ^{177}Lu-based therapy treatment planning is based on a theranostic approach which consists in several steps.

First, a pre-treatment PET imaging is acquired to evaluate the biological targets in patients before starting their treatment. The standard approach for this step is composed of conventional *static* PET images acquired usually 60 minutes post injection of ^{68}Ga labeled tracer.
Second, after this first planning phase, the treatment itself is administrated by ^{177}Lu injection. Ideally, several SPECT images are acquired, e.g. 4h, 24h and 96h post-injection, in order to obtain information about the biodistribution and the pharmacokinetic of the radiolabeled molecule. These information are the basis for deriving personalized dosimetry, which is crucial to better understand treatment efficacy and predict potential toxicity. However, such per-treatment SPECT acquisitions are time consuming and difficult to manage in practice.

The conventional pre-treatment static PET images provide semi-quantitative analyses of uptake at a voxel or organ-level in the target volumes but not a true quantification of patient metabolism nor a thorough dynamic physiological processes, also named *parametric* information [2, 3]. This parametric information is expected to be superior to the information obtained by conventional *static* PET imaging and holds great potential in a theranostic approach. However, the limited axial field of view and the lack of user-friendly clinical software for data analysis have limited the dynamic acquisitions implementation into clinical routine [4,5].

The recent development of SiPM-based PET, or so-called “digital PET”, offers better spatial and temporal resolutions and sensitivity and is likely to improve *dynamic* PET acquisition quality to reconstruct maps of kinetic parameters related to the metabolism of the injected tracer.

In this context, we propose to investigate the interest of parametric digital PET imaging in a theranostic approach for ^{177}Lu-based treatments. Ideally, correlation between parametric PET and per-treatment SPECT images and associated dosimetry will be studied in order to derive recommendations.

[1] joint nuclear medicine department of Léon-Bérard comprehensive cancer center and Hospices Civils de Lyon

Database

We will focus on ^{177}Lu-PSMA treatments, an innovative treatment for metastatic castration-resistant prostate cancer that uses ^{177}Lu conjugated to ligand PSMA-617. Prostate-specific membrane antigen (PSMA) is a cell membrane glycoprotein that is selectively expressed in prostate cells, with high expression levels in prostatic adenocarcinoma. In a clinical study starting in our department, patients will have both pre-treatment ^{68}Ga parametric PET images and several per-treatment ^{177}Lu SPECT acquisition allowing complete personalized dosimetry. It is however expected that, in future studies, the number of SPECT acquisitions will be reduced due to time and clinical constraints. This database will thus be one of this kind allowing to investigate PET and SPECT dosimetry information relationship.

Objectives

1) First, optimize the dynamic acquisition parameters for the Siemens Digital Biograph Vision 450 PET/CT. In particular, investigate the acquisition protocol to obtain ^{68}Ga image over a large patient field of view, corresponding to the one of the subsequent SPECT image. To that end, experimental measurements will have to be performed. The parameters obtained will be implemented in a clinical practice at LUMEN nuclear medicine department.

2) Investigate correlation between parametric PET images and ^{177}Lu-treatment dosimetry based on per-treatment SPECT images. This work will be carried out in collaboration with a parallel study on dosimetry ^{177}Lu underway in our research team.

Keywords

Theranostic, parametric PET imaging, digital PET, personalized radionuclide therapy

Environment

The recruited PhD student will work in a multidisciplinary team composed of nuclear physicians, medical physicists, radiopharmacists, researchers and computer scientists of CREATIS laboratory, Leon-Bérard and HCL cancer centers. This study will give the student the opportunity to work in both imaging and dosimetry in the field of nuclear medicine.

Recommended skills

- **Education**: master in medical physics, applied mathematics or image processing.
- **Scientific interests**: medical physics, applied mathematics, computer sciences (medical image processing), x-ray and nuclear physics and imaging.
- **Programming skills**: Python highly recommended
- **Languages**: English required, French optional.

Practical information

- **Supervisors**: David Sarrut (david.sarrut@creatis.insa-lyon.fr) and Jean-Noël Badel (jeannoel.badel@lyon.unicancer.fr)
- **Location:** CREATIS Lab, Centre Léon Bérard, Lyon, France
- **Salary (net):** around 1800 euros/month (tbd). CIFRE with Siemens
- **Period:** three years starting September 2021.

How to apply?

Send CV + covering letter outlining your motivation + grades in master. If possible: recommendation letters from previous supervisors or teachers.

References

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