Dual energy CT (DECT) to assess calibration uncertainties in the conversion of Hounsfield Units (HU) into Stopping power ratios (SPR) for proton therapy in patients with implanted materials

The physical benefit of proton therapy compared with photon therapy can contribute to high tumor coverage while sparing normal tissue more effectively. To improve the clinical exploitation of theoretic advantages, current uncertainties in proton range prediction from computed tomography (CT) have to be further minimized. Inasmuch as proton treatment planning today is based on single-energy CT (SECT), CT-related uncertainties and the heuristic conversion of CT numbers into stopping-power ratios (SPRs) using a universal Hounsfield look-up table (HLUT) limit treatment accuracy. Additional margins of about 3.5% of absolute range are clinically used in beam direction to take account of these uncertainties. It has been shown that dual-energy CT (DECT) can potentially contribute to more precise proton range predictions. However, current findings are mainly based on DECT scans of homogeneous tissue substitutes and simplified inhomogeneous phantoms, which were tested retrospectively on a few DECT scans of head trauma patients acquired with nonoptimized DECT protocols for radiation therapy. Although voxelwise DECT-based SPR prediction approaches are subject to intensive research activities, they are not yet clinically validated and applied because several challenges, for example, integration into commercial treatment planning systems (TPS), are still to be solved. Hence, a stepwise clinical implementation of DECT is highly advisable if not even inevitable.

We propose here an approach, starting with treatment planning on DECT-to quantify calibartion uncertainties between CT-number-to-SPR conversion and range prediction similar with DECT versus DECT based on commonly implanted materials in patients undergoing proton therapy at our center.

Material and methods

- Establish Physics uncertainties (SPR, proton range) with the CFB / CYCLHAD team
- Material : different +/- dense materials (from plastic to bone equivalent or metal including hip replacement or dental filling materials), anthropomorphic phantom
- Access to conventional single energy CT at Baclesse (radiotherapy), and dual energy CT at University hospital (radiology)

Learning objectives

- Understand a Calibration process
- Design the technical protocol with the different material samples
- Understand dose calculation in radiotherapy and understand the impact of proton therapy uncertainties on patient treatment
- Be able to explain the advantages of DECT / MECT over single energy planning CT
- Propose perspectives (use of DECT for PT planning) ; potential participation in scientific publication

Supervisors :

- Pr Juliette Thariat
- Along with physicists and radiologists

Working places (all within 15 minute walk from one another)

1. Centre François Baclesse Cancer Center / Proton therapy center CYCLHAD
2. University Hospital (DECT)

3. LPC Laboratoire de Physique Corpusculaire
4. GREYC

For further reading

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