ESTRO's EPTN WP5 enables unique inter-centre comparison study: quantification of variation in range prediction between European proton centres

What was the motivation for initiating this study?

Proton therapy enables a highly precise placement of dose within the target volume while sparing surrounding healthy tissue. Dose calculations are performed on computed tomography (CT) scans of the patient. The CT numbers from the patient images are converted into tissue information (for proton therapy, this is the stopping power) using a heuristic conversion to calculate the proton range.

This conversion is defined and validated by each treatment facility individually, and while extensive literature on the topic exists, no comprehensive standard has been established for centres to follow. As a consequence, a relevant variation in proton range prediction between different centres cannot be ruled out. This not only affects the treatment outcome for the individual patient, but also the comparability of clinical data from different facilities.

In our study we quantified experimentally the variation between European particle centres in stopping power prediction, and consequently range, for the first time. The fifth working party (WP5) of the European Particle Therapy Network (EPTN) under the European SocieTy for Radiotherapy and Oncology (ESTRO) initiated this project and the majority of the European centres – 17 in total – took part.

What were the main challenges during the work?

The heuristic conversion from CT number to stopping power heavily depends on the clinical CT scan setup, so it is not sufficient to simply compare the conversion curves. Instead, every study participant was required to scan a study phantom using their clinical CT protocol. That required quite some logistical effort, especially when the phantom had to be sent across EU borders. Luckily, there were only short delays, and all participants took great care of the phantom.

The study phantom itself, which consisted of a head-and-body geometry with different tissue surrogates, was manufactured specifically for this study to be tissue-equivalent not only for photons (and therefore CT imaging) but also for protons. This was necessary because no commercially available phantom fulfilled the required level of tissue-equivalence.

While the determination of the variation was straightforward, the main challenge was to trace back the underlying error sources, as the conversion curve definition is influenced by a variety of factors. To do so, each participating centre was willing not only to discuss the individual results, but to provide in-depth insights into and their clinical procedures. This way, it was possible not only to quantify the status quo in range prediction within the European particle therapy community, but also to pin down the major issues for future improvement.

What is the most important finding of your study?

We determined a relevant 2σ variation in CT-based range prediction between the European treatment centres of almost 3% for both brain tumour and prostate cancer treatment. This variation is on the same level as the safety margins that are typically applied in proton treatment planning.

In the aftermath of the study, a third of the participating centres reported that they would re-evaluate their clinical range prediction procedure; consequently, several centres updated their implementation.

What are the implications of this research?

The study stresses the need for the establishment of guidelines for CT-based range prediction to improve both individual patient care and the comparability of data that are obtained from different treatment centres. In a joint effort of EPTN WP5 and this year's ESTRO physics workshop "Clinical translation of CT innovations", the definition of such guidelines is currently underway.

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ESTRO physics workshop: https://www.estro.org/Workshops/2020-Physics-Workshop-Science-in-Development/Clinical-Translation-of-CT-Innovations-in-Radiatio

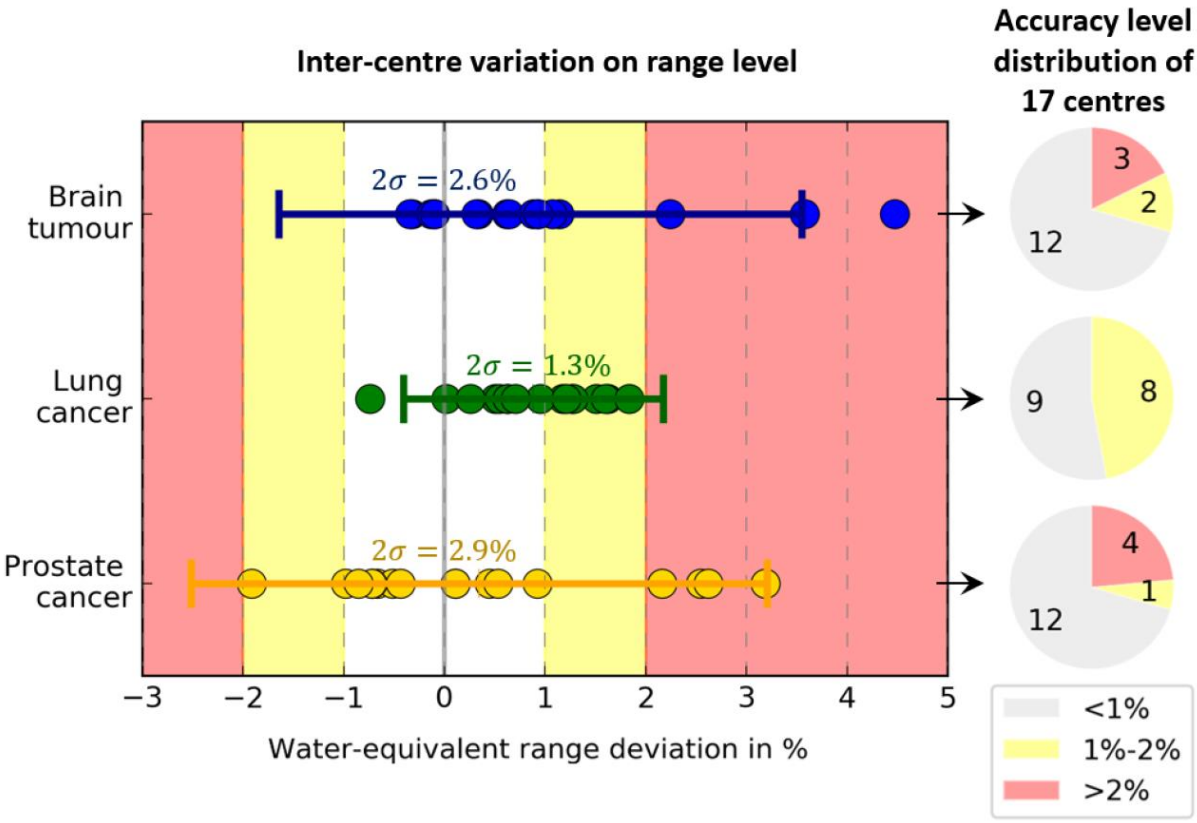

Figure 1: *Variation in range prediction between 17 European proton centres for different body sites. Each data point represents one centre.*

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