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ESTRO 2023 Physics Track - Dose accumulation and dose prediction

A multi-institutional analysis of retrospective deformable dose accumulation for online adaptive MR-guided radiotherapy'

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What was your motivation for initiating this study?

Deformable dose accumulation (DDA) in adaptive radiotherapy (ART) is not yet widely used clinically, because of potential uncertainties in dose-mapping strategies and the impact of these uncertainties on patient safety [1]. However, DDA promises precise evaluation of radiation doses that are delivered to each organ, which might lead to a reduction of toxicity caused to organs-at-risk [2-4], dose tolerances that are more precisely determined than is possible currently [5], and/or additional target-dose escalation [4]. Comparison of DDA across institutions is difficult due to differences in the DDA algorithms that are used, as demonstrated by several magnetic resonance-guided radiotherapy (MRgRT) DDA studies [6,7]. The comparison of different DDA algorithms used in stereotactic MRgRT of the liver and prostate showed that the results are highly patient-, fraction- [6], and methods-dependent [7].

The goal of our multi-institutional analysis was to compare different DDA software implementations, examine differences in the resulting dose metrics, and recommend workflows that led to robust and accurate calculation of DDA in clinical MRgRT. This multicentre DDA study was performed by a working group of the Elekta MR-Linac consortium, which consists of six institutes. This study was of five clinical datasets of cancer patients with tumours in different anatomical regions: cervix, liver, lymph nodes, and prostate cancer (two cases). These patients had been treated previously through the use of stereotactic MRgRT on the 1.5T MR-Linac system (Unity, Elekta AB, Sweden) with application of the adapt-to-shape workflow. Each participating institute performed DDA through the use of the software that was available at that institute.

What is the most important finding of your study?

Overall, a good agreement was observed among the different approaches that were used to determine DDA at the participating institutes. The percentage of clinical dosimetric constraints for which the accumulated doses did not deviate by more than ±5% from the median was 93%, 87%, 79%, 88%, and 92% for cervix, liver, lymph node, and prostates 1 and 2, respectively.

The results suggest that knowledge of DDA in online adaptive MRgRT offers an accurate assessment of target- and organ-specific accumulated doses, particularly during the use of hybrid algorithms that include contour guidance of the deformable image registration (DIR) algorithm. Variations in dose accumulation results were caused by the use of different DIR algorithms (without contour guidance), absolute volumes of organs of interest, and case-specific requirements.

What are the implications of this research?

Characterisation of DIR and DDA accuracy and between-algorithm variability is critical for the future integration of accumulated dose metrics in the online adaptive framework. The results of our study may have important implications for potential future interventions or adjustments of plans based on these DDA algorithms. We continue to work on studies to advance the clinical use

of DDA for online ART. In addition, we are investigating robust methods that can be used to quantify DIR and DDA uncertainty in order to identify areas of variation in the future.

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