

ABSTRACT

Is dose accumulation required? Implications of adaptive dose guidance.

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The planning image is only a snapshot of the patient anatomy at that point in time. It does not represent the anatomy during the entire treatment process, and thus the planned dose is rarely the same as the actually delivered dose to the patient. Additionally, the true dose distribution in normal tissue, accumulated over the whole treatment process, is likewise poorly quantified. Knowledge of the true dose delivered to organs would allow the opportunity for “dose guided adaptive radiotherapy”. The goal of “dose guided adaptive radiotherapy” is to achieve better tumor control while keeping the normal tissue toxicity to within typical tolerance levels.

In chapters 1 and 2, we studied if deformable image registration (DIR) helped to estimate total delivered dose for prostate patients treated with or without balloons inserted into the rectum. This was done by comparing the fractional and total delivered dose dose volume histograms (DVHs) to planned DVHs. The results showed DIR errors were acceptable for patients treated with balloons, but not for those treated without. We further studied how setup parameters affect the dose delivery for patients treated with balloons.

We then did a dosimetric-predictor study using a cohort of prostate cancer patients with long term follow up in chapter 3. We fitted a NTCP, or “normal tissue complication probability” model using the planned dose and included a latency effect. Model tests showed that this NTCP model

did not predict clinically observed bleeding rates better than the QUANTEC model. Then we calculated the total delivered dose for all patients treated without balloons in the cohort, and compared the dosimetric predictors of total delivered and planned doses. Interestingly, 91% of the patients had a lower total delivered dose than planned.

The next step was to develop iso-NTCP dose guided adaptive planning strategies for qualified patients. Since any dose escalation to the target must be done in a conservative way, in chapter 5, we proposed a pretreatment test that uses “historical” images for iso-NTCP adaptive plan delivery and produce a 95% confidence interval for predicting the total delivered dose for the patients. We then “delivered” the adaptive plan using the “future” images, yielding the real total delivered dose. The pre-treatment test was able to conservatively predict what would be delivered on the “future” images. The total delivered dose for rectum was in typical tolerance levels. The maximum tumor control probability gain we saw was 6.3%.