

# Evaluation of simple MR-based online adaptive radiotherapy for prostate cancer

I. XHAFERLLARI<sup>1</sup>, D. LACK<sup>1</sup>, R. LEVITIN<sup>2</sup>, D. TO<sup>1</sup>, M. LIU<sup>1</sup>, J. LIANG<sup>2</sup>, D. KRAUSS<sup>2</sup> and D. YAN<sup>2</sup>

<sup>1</sup> Beaumont Health System, Troy, MI

<sup>2</sup> Beaumont Health System, Royal Oak, MI



## INTRODUCTION

For the Elekta Unity MR linac system, couch movement after daily imaging is not an option. Instead, users are to utilize an online adaptive radiotherapy solution to create a new daily plans. There are various adaptive strategies that can be applied with varying complexity and efficiency. In treatment of prostate cancer with radiotherapy, interfraction motion occurs due to variations in rectal and bladder filling. Simple online adaptive strategies are efficient and may be sufficient in treatment of prostate cancer with either hypofractionated or stereotactic prescriptions.

## AIM

The goal of this study is to evaluate if simple MR-based online adaptive radiotherapy planning strategies can be effectively implemented to account for prostate cancer treatment interfraction motion variation with either hypofractionated or stereotactic prescriptions.

## METHODS

- In this retrospective planning study, 5 prostate cancer patients with MR scans acquired prior to treatment, 2-weeks, and 3-months post were used.
- Two different fractionation schemes were used: hypofractionated (70Gy/28 fractions) and stereotactic (36.25Gy/5 fractions).
- The reference treatment planning dataset was the MR prior to treatment and remaining MRs were used as daily fractions.
- All plans were computed in Pinnacle v16.2
  - Appropriate anatomical density overrides were applied
  - To emulate the Elekta Unity system, plans were generated using 6XFFF and 7 step-and-shoot IMRT beams with 90° collimator angle.
- Rigid image registration was performed between the reference MR and the subsequent MRs
- Three simple adaptive strategies were performed<sup>1</sup>
  - Recalculation of original segments
  - Adapt segments by isocenter shift for new PTV
  - Adapt segments by isocenter shift and segment weight re-optimization using reference contours.
- Target and OARs were contoured on each MR
- Adaptive strategies were evaluated using NRG-GU005 objectives<sup>2</sup>.

## RESULTS

### HYPOFRACTIONATED DOSAGE

- All the OAR constraints were met while maintaining CTV coverage >95% using the original segments strategy (1)
- Adapt segments by isocenter shift to new PTV strategy (2) resulted in one failed OAR constraint with CTV coverage >99%.
- In strategy (3), adapt segments by isocenter shift and segment weight re-optimization using reference contours, CTV coverage was >99% but the plans are hotter and numerous OAR constraints failed (Table 1).

|                    |              | Adaptive Strategies (Hypofractionated) |     |     |
|--------------------|--------------|--|-----|-----|
|                    |              | (1)                                    | (2) | (3) |
| CTV: V70 ≥ 95%     |              | 0                                      | 0   | 0   |
| PTV D0.03cc<80.5Gy |              | 0                                      | 0   | 1   |
| Rectum             | D15%<80Gy    | 0                                      | 0   | 0   |
|                    | D25%<75Gy    | 0                                      | 0   | 1   |
|                    | D35%<70Gy    | 0                                      | 0   | 1   |
|                    | D50%<65Gy    | 0                                      | 0   | 0   |
| Bladder            | D0.03cc<75Gy | 0                                      | 1   | 5   |
|                    | D35%<73.5Gy  | 0                                      | 0   | 1   |
|                    | D50%<68Gy    | 0                                      | 0   | 0   |
|                    | D90%<40Gy    | 0                                      | 0   | 0   |

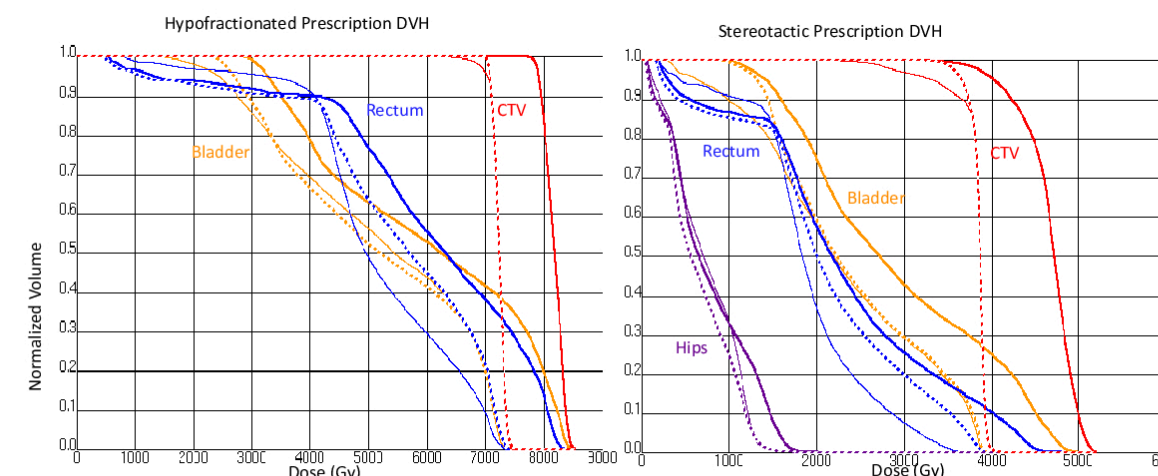
**Table 1.** Number of fractions failing to meet constraint criteria for each adaptive strategy using a hypofraction prescription.

### STEREOTACTIC DOSAGE

- Strategy (1), recalculation using the original segments, exhibited similar OAR failures to strategy (2), adapting segments by shifting the isocenter to the new PTV
- CTV coverage was >90% for all strategy (1) plans while it was >95% for all strategy (2) plans (Table 2).
- Using re-optimization of segments weights, although coverage was maintained, OAR dose was compromised in 60% of the fractions.

|                    |              | Adaptive Strategies (Stereotactic) |     |     |
|--------------------|--------------|------------------------------------|-----|-----|
|                    |              | (1)                                | (2) | (3) |
| CTV: V36.25 ≥ 95%  |              | 2                                  | 0   | 0   |
| PTV D0.03cc<43.5Gy |              | 0                                  | 0   | 3   |
| Rectum             | D0.03cc<40Gy | 2                                  | 0   | 4   |
|                    | D3cc<36Gy    | 2                                  | 1   | 4   |
|                    | D10%<34Gy    | 2                                  | 2   | 3   |
|                    | D20%<30Gy    | 1                                  | 1   | 3   |
| Bladder            | D50%<19Gy    | 2                                  | 2   | 4   |
|                    | D0.03<40Gy   | 1                                  | 4   | 4   |
| Hips               | D1cc<15.6Gy  | 0                                  | 0   | 4   |

**Table 2.** Number of fractions failing to meet constraint criteria for each adaptive strategy using a stereotactic prescription.



**Figure 1.** Dose volume histogram for N=2, two week post MRI scan using hypofractionated (a) and stereotactic (b) dosage demonstrating a worst-case scenario in the differences between the three adaptive strategies.

## DISCUSSION AND CONCLUSIONS

- Three adaptive strategies with increasing complexity were analyzed:
  - Recalculation of original segments
  - Adapt segments by isocenter shift to new PTV,
  - Adapt segments by isocenter shift and segment weight re-optimization using reference contours.
- Original segments is computed by rigid translation only alignment to emulate daily imaging without couch rotation. However, in the MR-linac, couch movement is not an option, and results observed here are a best case scenario.
- Dose in strategy 3 was re-normalized to obtain coverage to the reference CTV leading to hotter plans
- In the hypofractionated regimen, simple adaptive strategies, specifically strategy 1 and 2, provide sufficient CTV coverage and maintain similar OAR sparing
- In stereotactic dosing scheme full replanning is warranted.

## REFERENCES

- <sup>1</sup> Winkler D et al. "Adaptive radiotherapy: the Elekta Unity MR-linac concept." *Clinical and translational radiation oncology* 18 (2019): 54-59.
- <sup>2</sup> Ellis R D et al. Phase III IGRT and SBRT vs IGRT and Hypofractionated IMRT for Localized Intermediate Risk Prostate Cancer – NRG-GU005, October 18, 2017

## CONTACT INFORMATION

Ilma.Xhaferllari@Beaumont.org