Novel Approach: Adaptive MR-Guided SABR as an alternative to HDR Brachytherapy Boost in Gynaecological Cancers

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Background

Curative treatment for locally advanced cervical cancer is chemo-radiation with external beam radiotherapy (EBRT) and brachytherapy. However, brachytherapy is not always feasible due to patient factors, including refusal, procedural complications or technical challenges. It is well established that survival in patients who are unable to undergo brachytherapy and receive EBRT boosts is worse and therefore efforts are needed to improve the alternative treatment options in this situation.

Magnetic Resonance (MR)-Guided stereotactic adaptive radiotherapy (SABR) adapts dose to daily anatomical variations, with superior soft tissue contrast, continuous intrafraction tracking, reduced PTV margins and allows for dose escalation. This is therefore an appealing approach in gynaecological cancers due to the intrafraction and interfraction motion as well as close proximity to organs at risk (OARs; bladder and rectum).

We therefore undertook a planning study to assess whether MR-Guided SABR could replicate doses similar to those delivered in cervix brachytherapy boosts.

Method

Eight cases were retrospectively planned. High risk clinical target volume (HRCTV) as per GEC ESTRO recommendations was outlined as well as the OARs to include bladder, rectum and bowel by one clinical oncologist and reviewed by a second independent clinical oncologist. CTV to planning target volume (PTV) margin was 3mm. Dose prescription was 30Gy/5#s to PTV, simultaneously boosting CTV to 35Gy. It was assumed all patients received 45Gy/25# or EBRT with 0% OAR recovery. Maximum PTV dose was limited at 1 cc at 150% of 35Gy. EMBRACE-II 2cc OAR constraints were applied (bladder 90Gy, rectum/bowel 70Gy) and 0.1cc dose constraints to displace hotspots. Projected cumulative dose was calculated using α/β ratio of 5 for bladder/rectum, and 4 for bowel. Minimum cumulative EQD2 target coverage was:

- D90% CTV≥90Gy
- D90% PTVhigh≥85Gy
- D90% PTV≥80Gy

Test No	Px	Vol_CTV (cc)	D98% Boost CTV EQD2 (Gy)	D98% Boost PTVhigh EQD2 (Gy)	D98% Boost PTV EQD2 (Gy)	D90% Total CTV EQD2 (Gy)	D90% Boost PTVhigh EQD2 (Gy)	D90% Total PTVhigh EQD2 (Gy)	D90% PTV Cum EQD2 (Gy)	Prescription Dose Spillage	Estimated Delivery Time (minutes)	Global D-Max (Gy)
1	30Gy/5# 35Gy CTV Boost	13.1	45.0	35.8	29.3	99.4	42.7	87.0	81.4	1.05	10.5	53.2
2	30Gy/5# 35Gy CTV Boost	27.0	40.5	35.9	27.5	93.4	43.2	87.5	79.7	1.03	11.0	54.1
3	30Gy/5# 35Gy CTV Boost	40.0	40.8	37.7	28.4	96.4	43.4	87.6	81.1	1.04	9.0	53.1
4	30Gy/5# 35Gy CTV Boost	27.9	38.4	39.3	26.4	93.2	47.3	91.6	79.9	1.07	12.0	55.3
5	30Gy/5# 35Gy CTV Boost	59.4	35.2	33.6	24.6	84.0	39.7	83.9	73.7	1.05	10.8	53.3
6	30Gy/5# 35Gy CTV Boost	31.9	49.8	38.9	28.3	100.9	44.9	89.2	87.4	1.09	8.1	51.3
7	30Gy/5# 35Gy CTV Boost	82.3	37.1	36.2	28.2	91.8	41.8	86.0	79.8	1.03	11.8	54.6
8	30Gy/5# 35Gy CTV Boost	121.7	35.9	35.1	23.6	91.8	43.1	87.3	78.4	1.06	8.7	53.6
Average		**50.4**	**40.3**	**36.6**	**27.0**	**93.9**	**43.3**	**87.5**	**80.2**	**1.05**	**10.2**	**53.6**
St Dev		**36.0**	**5.0**	**2.0**	**2.0**	**5.3**	**2.2**	**2.2**	**3.8**	**0.0**	**1.5**	**1.2**

Table 1: The following data is derived from eight test Gynae MRgRT boost trials, which were conducted as an alternative to HDR BT

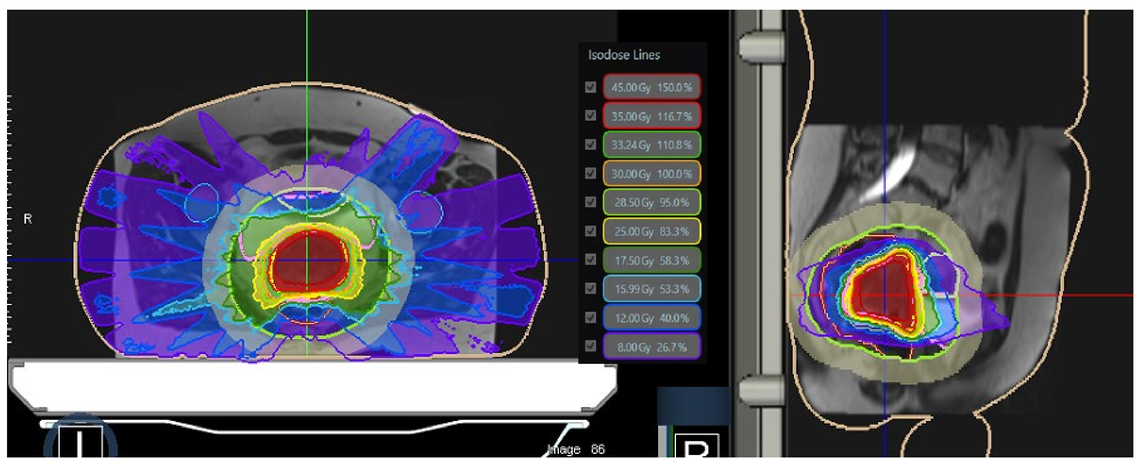

Figure 1: Example images of MR- Guided SABR boost plan with dose distribution

Results

Mean CTV volume was 50.4cc (range 13.1–121.7).

Mean combined EQD2 D90% for CTV was 93.9Gy (range 84.0-100.9)

Mean combined EQD2 D90% for PTV high was 87.5Gy (range 83.9-91.6).

Maximum doses inside CTV reached 55.3Gy (158% of 35Gy).

Regarding OARs, the maximum (median) 2cc OAR doses to the bladder, rectum and bowel were 84.6Gy (79.3), 69.9 (69.7) and 69.5Gy (64.3) which were all within the mandated EMBRACE II parameters. Rectum was the dose limiting structure.

Data for each individual case is recorded in Table 1 and mean values are displayed on Figure 2.

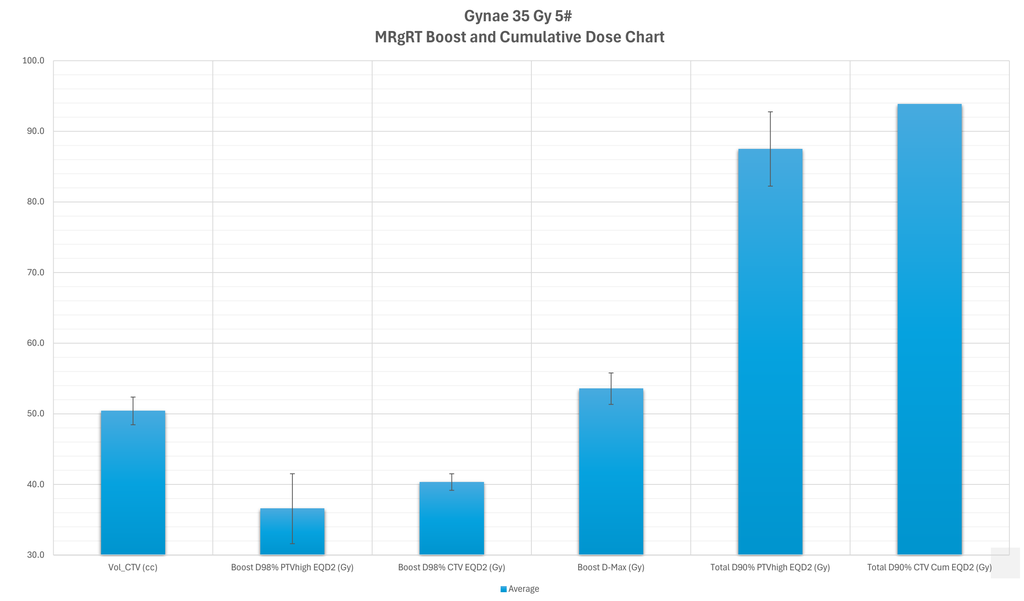

Figure 2: The mean values for boost and cumulative dose coverage for PTVhigh and CTV, as well as the standard deviations, for all eight test MRgRT trials

Conclusion

Adaptive MR-Guided SABR Boost for gynaecological cancer has demonstrated good target coverage within OAR constraints similar to brachytherapy. This supports clinical feasibility of using the MR Linac to deliver external beam boosts in patients unable to undergo brachytherapy. With the use of this technology to escalate dose it may improve survival and reduce the disparity in survival outcomes between EBRT boosts and brachytherapy.

References

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