Dosimetric uncertainties due to inter-fraction organ at risk movement in HDR cervical brachytherapy

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Purpose

To investigate the requirement for in vivo dosimetry in HDR cervical brachytherapy by:

1. Assessing the effect of inter-fraction organ at risk (OAR) movement on dosimetric parameters
2. Identifying the OAR subsections which experienced the most mobility and dosimetric variation with the view to determining the optimal positions for in vivo dosimeters during brachytherapy.

Methods

20 consecutive patients who underwent three fractions of MRI/CT-guided brachytherapy at the Northern Ireland Cancer Centre were included.

Organs at risk (OARs) of interest were bladder, rectum and bowel. The bladder and rectum were divided into subsections of superior, middle and inferior along divisions of the upper, middle and lower third of the high risk clinical target volume (HRCTV) (Fig. 1).

Dosimetric parameters for each OAR and subsection were calculated for the pre-fraction 2 and 3 CTs and compared to the pre-fraction 1 CT.

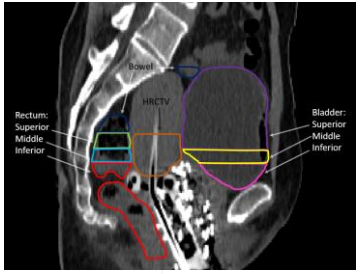

Fig. 1. Sagittal view of the female pelvis with ring and tandem applicator in situ illustrating the methods of division of the bladder and rectum into subsections.

Results

The D2cc of the pre-fraction 2 and 3 CTs were within 10% of the pre-fraction 1 CT D2cc dose in 20%, 18% and 50% of fractions for the superior, middle and inferior bladder respectively and within 10% in 20%, 34% and 45% of fractions for the superior, middle and inferior rectum respectively. Fig. 2 depicts the percentage of fractions where the pre-fraction 2 and 3 CTs were within X% of the pre-fraction 1 CT for the whole bladder, rectum and bowel.

The mean differences (± SD) of the D2cc of the pre-fraction 2 and 3 CTs compared to the pre-fraction 1 CT were -24% (±39%), -8% (±32%) and -2% (±19%) for the superior, middle and inferior bladder respectively and +7% (±49%), +7% (±30%) and +8% (±29%) for the superior, middle and inferior rectum respectively.

Percentage deviations in D2cc for bladder subsections ranged from -100% to +28% (superior), -100% to +89% (middle) and -44.5% to +97% (inferior). Percentage deviations in D2cc for rectum subsections ranged from -100% to +127% (superior), -48% to +112% (middle) and -25.9% to +107% (inferior).

At a prescription dose of 7 Gy for each fraction, the bladder dose constraint of 90 Gy_{EQD2} (α/β=3) was exceeded in 40% (8/20) of treatment courses and the rectum and bowel dose constraint of 75 Gy_{EQD2} (α/β=3) was exceeded in 45% (9/20) and 50% (10/20) treatment courses respectively.

To keep the dose to OARs within acceptable constraints, dose reduction was required for all three brachytherapy fractions in 35% (7/20) of patients, for two fractions in 15% (3/20) of patients and for one fraction in 15% (3/20) of patients.

Conclusions

Inter-fraction OAR motion occurs in cervical brachytherapy and can necessitate prescription dose reduction. The superior and middle subsections of the rectum and bladder experienced the greatest percentage deviations on the pre-fraction 2 and 3 CTs compared to the pre-fraction 1 CT. Dosimeters should be placed in a range of locations within the rectum and bladder at the level of the HRCTV.

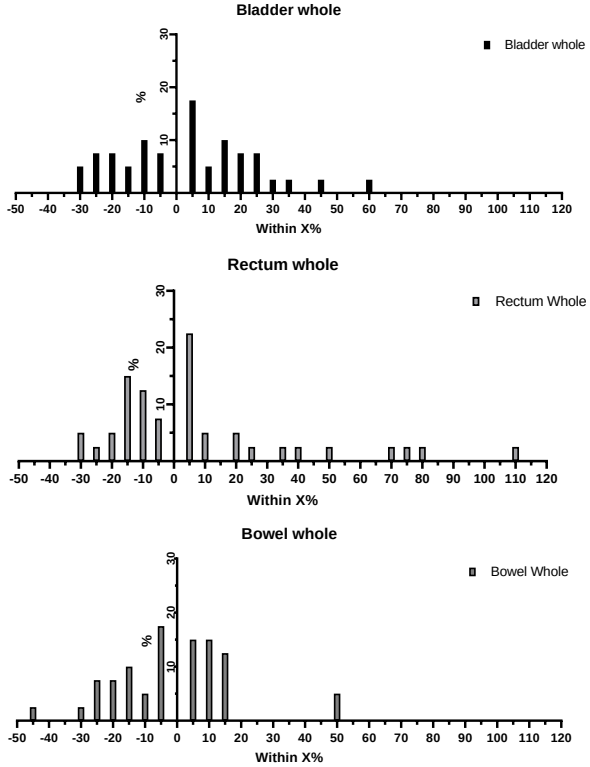

Fig. 2. Percentage fractions of the pre-fraction 2 and 3 CTs (n=40) in which the D2cc of OARs were within X% of the D2cc of the pre-fraction 1 CT.

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