Effects of simulated systematic applicator displacement in intra-cavitary HDR cervical brachytherapy

Orla A Houlihan[1,2], Monica Byrne[3], Owen McLaughlin[1,3], Geraldine Workman[3], Sergio Esteve[3], Ursula McGivern[2], Anne Drake[2], Elizabeth Baird[2], Kevin M Prise[1], Alan R Hounsell[3], Suneil Jain[1,2]

1. Patrick G. Johnston Centre for Cancer Research, Queen's University Belfast, Belfast, Northern Ireland
2. Department of Clinical Oncology, Northern Ireland Cancer Centre, Belfast City Hospital, Belfast, Northern Ireland
3. Department of Radiotherapy Medical Physics, Northern Ireland Cancer Centre, Belfast City Hospital, Belfast, Northern Ireland

Purpose

To simulate systematic applicator displacements in intra-cavitary HDR cervical brachytherapy with the view to determining the required accuracy of in vivo dosimeters, developed as part of the EU H2020 ORIGIN project [1].

Methods

20 CTs performed prior to the first fraction of intra-cavitary HDR cervical brachytherapy were included. Organs at risk of interest were bladder, rectum and bowel. The bladder and rectum were divided into sections of superior, middle and inferior along divisions of the upper, middle and lower third of the high risk clinical target volume (HRCTV) (Fig. 1).

The ring and tandem applicator was systematically displaced in 1 mm increments from 1-6 mm in cranial, caudal, anterior, posterior, left and right directions along the plane of the central tandem to simulate applicator displacement between planning CT and brachytherapy delivery.

The D2cc (minimum dose to the most irradiation 2cc) was calculated for each displacement and compared to the original planning CT.

Results

The greatest mean increases in D2cc occurred in the anterior direction for bladder and posterior direction for rectum, with increases of 5 ± 2%, 19 ± 4% and 37 ± 9% to bladder and 3 ± 2%, 12 ± 5% and 25 ± 9% to rectum for 1, 3 and 5 mm shifts in each respective direction. The greatest mean increases in bowel D2cc occurred with posterior displacement with increases of 3 ± 3%, 12 ± 8% and 26 ± 14% for 1, 3 and 5 mm shifts respectively.

The inferior bladder experienced the greatest percentage change in D2cc with 1, 3 and 5 mm anterior shifts resulting in mean increases of 5 ± 2%, 17 ± 3% and 34 ± 7% respectively. The middle part of the rectum experienced the greatest percentage change in D2cc with 1, 3 and 5 mm posterior shifts resulting in mean increases of 3 ± 2%, 13 ± 3% and 27 ± 7% respectively.

Wide deviations in mean D2cc occurred with increasing displacement, with shifts of 6 mm resulting in changes of 49 ± 11%, -21 ± 4% and -8 ± 9% in the anterior, posterior and right directions for the bladder, 28 ± 6%, 44 ± 14%, -15 ± 6%, 32 ± 12%, -13 ± 6% and -8.5±6.9% in the cranial, caudal, anterior, posterior, left and right directions for the rectum and 34.1±17.5% in the posterior direction for the bowel.

Displacements in the caudal and left directions had the least mean changes for bladder at 2.4±2.3% and 3.6±7.4% at 6 mm respectively. Displacements in the cranial and caudal directions had the least mean changes for bowel at -1.0±6.3% and -0.5±5.6% at 6 mm respectively.

Conclusions

The greatest mean increase in dose to bladder occurred with displacements anteriorly and to rectum and bowel posteriorly, in keeping with anatomical locations. Applicator displacements as small as 1 mm can result in increases in D2cc of >5% and dosimeters should have the ability to detect displacements at least as small as this. The effect of applicator displacements on bladder and rectum subsections is important for determining the optimal positions for dosimeters.

References

1. ORIGIN 2020 Project. Available from: https://origin2020.eu

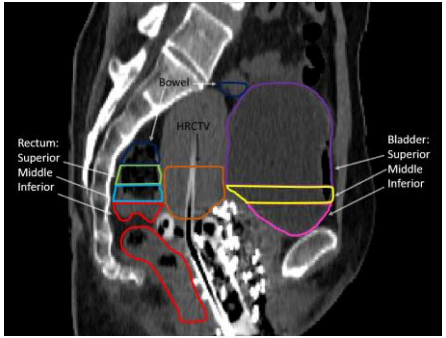

Fig. 1. Sagittal view of the female pelvis with ring and tandem applicator in situ illustrating the methods of division of the bladder and rectum into subsections.

The ORIGIN project is an initiative of the Photonics Public Private Partnership (www.photonics21.org), and has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement n° 871324