The dosimetric impact of interstitial needles in HDR brachytherapy for cervical cancer

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Introduction and Objectives

- Image guided brachytherapy (IGBT) is an essential component of the treatment of locally advanced cervical cancer.
- Dose escalation has been shown to improve survival in these patients.
- Interstitial needles are indicated for bulky tumours or in patients with unfavourable topography due to close proximity of organs at risk (OAR). However, template interstitial implants are complex to insert and plan.
- The use of applicator interstitial implants allows dose sculpting to be more individualised than the classic 'pear shape' dose distribution from intra-cavitary brachytherapy alone.
- We retrospectively reviewed the use of interstitial needles at our institution and assessed the impact of interstitial needles on dosimetry to the high-risk clinical target volume (CTV_{HR}) and OAR.

Methods

- Patients who received intracavitary brachytherapy for cervical cancer between August 2014 and February 2017 were identified from the brachytherapy database.
- Clinical and dosimetric data was collected on all patients.
- Patient were grouped into the intra-cavitary cohort (IC cohort) or the intra-cavitary and interstitial implant cohort (IC/IS).
- 10 patients who had been treated with interstitial needles for all three fractions of brachytherapy (IC/IS plan) had their brachytherapy replanned without interstitial needles (IC plan).
- The total D90% received by the CTV_{HR} and the $D2cm^3$ to the bladder, bowel, sigmoid and rectum was compared for each patient to assess the contribution of the needles to the overall dose received.
- Dose reporting was based on the total (external beam radiotherapy and brachytherapy) biologically equivalent dose in 2 Gy fractions (EQD2) using the linear quadratic model with α/β = 10 Gy for tumour and α/β = 3 Gy for OAR.

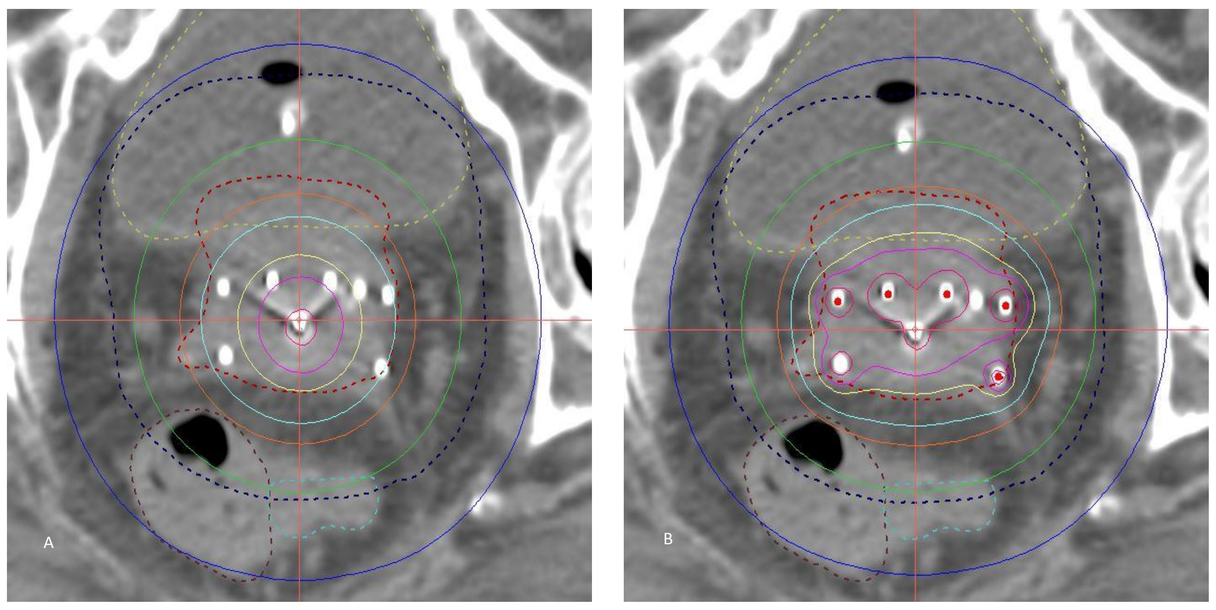

Figure 2 – Axial slice of a brachytherapy planning CT scan for a patient with bladder involvement.
(A) IC plan – no catheters used and therefore the dose distribution is circular at this level emanating from the tandem
(B) IC/IS plan - 7 catheters were loaded which allowed the dose to be sculpted and therefore allowed better coverage anteriorly where the tumour invades into the bladder whilst sparing the rectum and the sigmoid posteriorly.
The CTV_{HR} is depicted in a dashed red line, the bladder in yellow, rectum in brown and sigmoid in light blue.

Results

- 42 patients were identified.
- 31 patients (74%) were treated with an intra-cavitary implant and interstitial needles for at least one fraction (IC/IS cohort).
- 61.3% of patients in the IC/IS cohort had CTV_{HR} volumes ≥$30cm^3$ at fraction 1 compared to 18.2% in the IC cohort (p=0.014).
- There was no statistically significant difference in cumulative D90% to CTV_{HR} between the IC/IS cohort and the IC cohort (mean 84.8Gy +/- 5.2 and 86.2Gy +/- 10.5 respectively).
- For the patients who had their brachytherapy fractions replanned, the cumulative CTV_{HR} D90% was on average 5.8Gy higher when interstitial needles were used (mean CTV_{HR} D90% 86.1 compared to 80.3Gy, p<0.001). The $D2cm^3$ to the OAR were not significantly increased (see figure 1 and table 1).

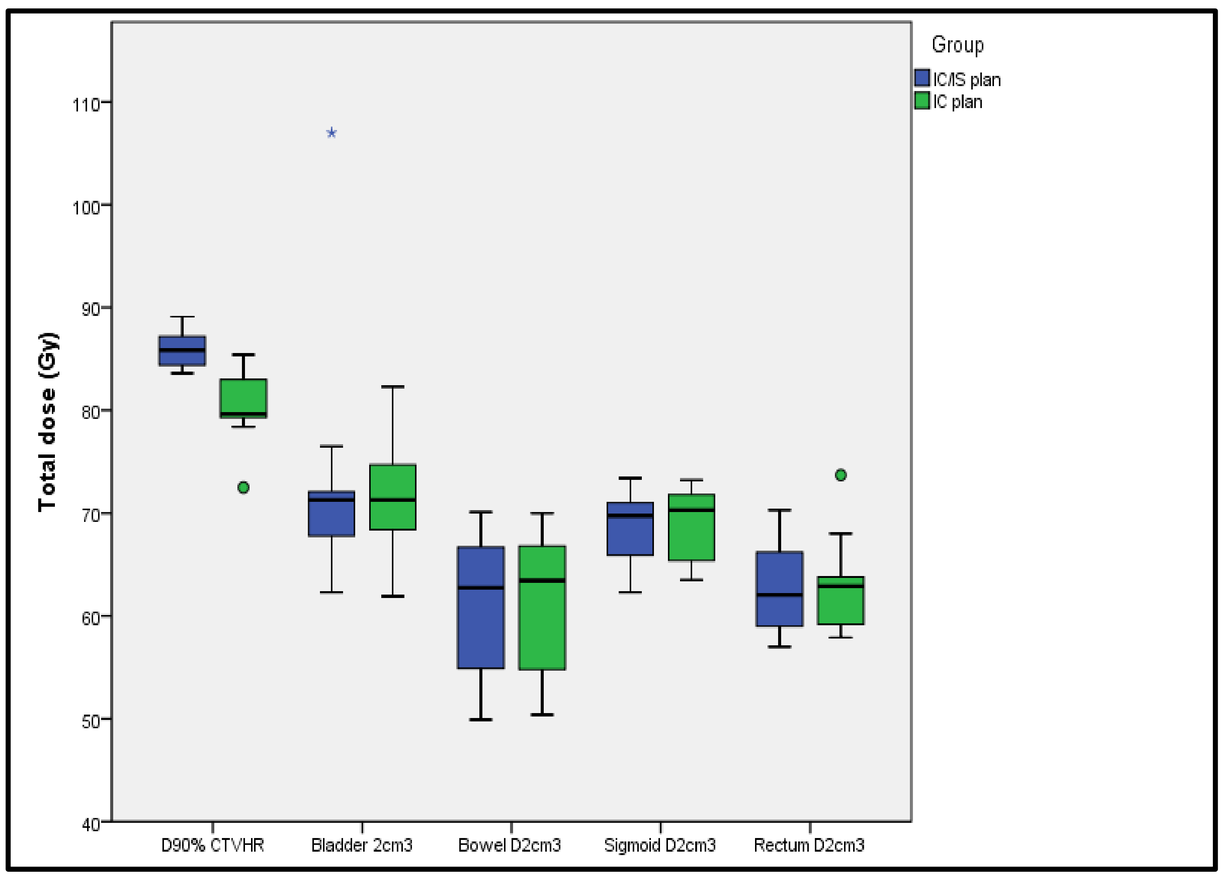

Figure 1 – A box plot to show the difference in D90% to CTV_{HR} and $D2cm^3$ to bladder, bowel, sigmoid and rectum between the IC/IS plan and the IC plan

	Total Dose (EBRT +IGBT)			p value
	IC/IS plans (Gy)	IC plans (Gy)	Mean difference (Gy)	
D90% to CTV_{HR}	86.1 +/- 1.8	80.3 +/-3.6	5.8+/-2.6	<0.001
$D2cm^3$ Bladder	73.4 +/- 12.5	71.7 +/- 5.9	1.7 +/-8.1	0.5
$D2cm^3$ Bowel	61.7 +/- 6.9	61.9 +/- 6.8	-0.2 +/-0.3	0.118
$D2cm^3$ Sigmoid	68.7 +/- 3.6	68.9 +/- 3.6	-0.2 +/-1.6	0.745
$D2cm^3$ Rectum	62.7 +/- 4.3	63.1 +/- 4.8	-0.4 +/-1.9	0.539

Table 1 – Dose received by the CTV_{HR} and OAR (mean +/- standard deviation) in 10 patients whose brachytherapy was planned with and without interstitial needles

Conclusion

The use of interstitial needles with intra-cavitary brachytherapy allows the dose to the CTV_{HR} to be escalated significantly without compromising on the dose to the bladder, bowel, sigmoid or rectum in patients with bulky tumours. Dose escalation in cervical cancer has previously been shown to improve survival and therefore the improvement in CTV_{HR} D90% due to the use of interstitial needles should ultimately lead to improved prognosis in patients with larger tumours.

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