A Comparison Study: Can Cervical Plans in Brachytherapy be Improved Using HIPO Over Forward Techniques?

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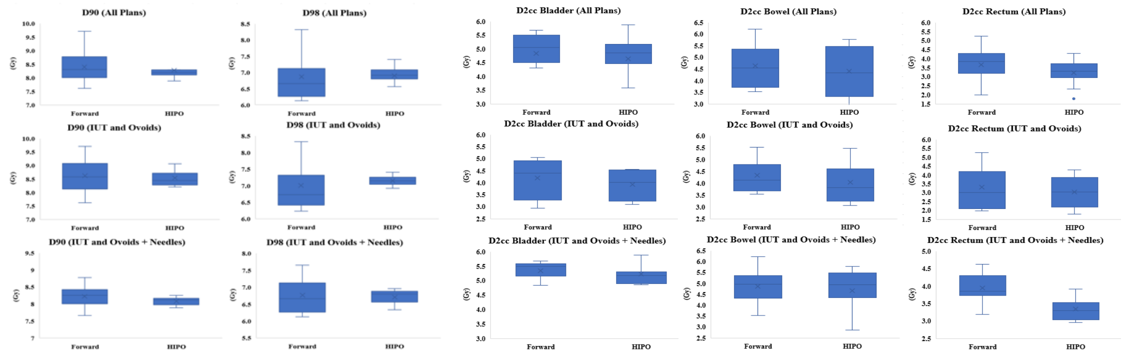
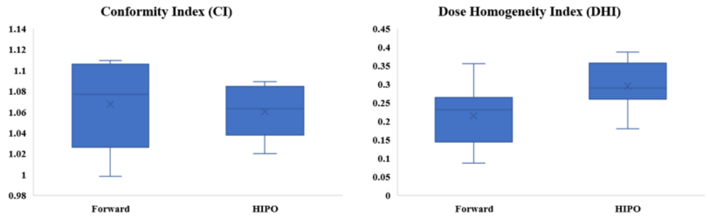
Aims. The overarching aim of this study is to investigate the feasibility of adopting inverse planning using HIPO (Hybrid Inverse Planning Optimisation) within our HDR (high-dose rate) brachytherapy clinic at the Exeter Oncology Centre. The primary focus is on evaluating the dosimetric differences of HIPO against GRO (graphical optimisation) and manual source dwell placement that is currently performed as part our department's forward planning procedure for cervical plans, to help guide whether it would be beneficial to integrate as an option within the planning workflow.

Methods. A cohort of nine historical patients who underwent a boost of HDR cervical brachytherapy were selected for this study that satisfied the case inclusion criteria of being image guided HDR plans. These plans were delivered with a standard prescription to Manchester point-A of 7 Gy over four fractions in three days. The plans consist of applicator setups consisting of just the IUT and ovoids, and those with needles. The HIPO license was activated on Oncentra Brachy and used to inversely optimise these plans. The dosimetric indices, D90 and D98 to the target and D2cc to the organs at risk were evaluated against the recommended GYN-ESTRO EMBRACE II guidelines [1]. Conformity and homogeneity indexes were determined, as well as the radiobiological parameters tumour control probability (TCP) and normal tissue complication probabilities (NTCP). The source-dwell times were summed within the intrauterine tube (IUT), ovoids and needles.

Results and Discussion. Overall, the D90 and D98 to the HR-CTV were comparable between the forward and inverse HIPO plans, with no statistically significant differences (p>0.05) observed between treatment configurations either with or without needles. The D90 and D98 also satisfied the minimum plan coverage aims in all cases as recommended by GYN GEC-ESTRO II protocol. As demonstrated visually by the boxplots, less variation in the HR-CTV coverage (in terms of D90 and D98) was observed with the HIPO plans. Only the rectum saw a significant increase in its D2cc in the HIPO plans (p=0.017).



There was no remarkable change in the mean conformity index in the HIPO plans than in forward planning. The mean dose homogeneity index was significantly higher by 38% across the HIPO generated plans (p = 0.012) than in the forward generated plans. This reflects that the algorithm covers the HR-CTV more uniformly in the 100% to 150 % prescription dose range.



There was a significant increase (p=0.048) in the TCP in the HIPO generated plans compared to the forward plans. The NTCP for all the OARs saw a decrease, 1.54 % for the bladder, 1.52 % for the bowel and 0.17 % for the rectum, however this was not statistically significant. The mean overall loading times were significantly reduced (p < 0.05) in the HIPO plans for both the plans without (p = 0.002) and with interstitial needles (p=0.028). For the IUT and ovoid setup, the total mean loading time decreased by 55 seconds, and with interstitial needles was decreased by 62 seconds. The IUT and ovoid mean loading times were both also significantly ($p < 0.05$) reduced in the plans containing needles, which was accompanied by an increase in the mean loading time within the needles. This suggests that HIPO tends towards dwelling the source for longer in the peripheral needles rather than in the IUT and ovoids.

Conclusion. Inverse planning with HIPO presents an option for optimising HDR cervical treatment plans. Through comparing the dosimetric parameters between the forward and inverse plans, only the D2cc to the rectum saw a significant reduction in the HIPO plans. Whilst the conformity indexes were similar, there was a significant increase in the dose homogeneity index. The loading time results express that the relative catheter weightings in the channels deviated greatly from local protocol, which may require the delineation of extra optimisation structures.

Key Words: For example: *HDR Brachytherapy, HIPO, Inverse Planning, Cervical*

Key references.

[1] Pötter R, Tanderup K, Kirisits C, et al. The EMBRACE II study: The outcome and prospect of two decades of evolution within the GEC-ESTRO GYN working group and the EMBRACE studies. *Clin Transl Radiat Oncol*. 2018;9:48-60. Published 2018 Jan 11. doi:10.1016/j.ctro.2018.01.001

Preliminary Approach to Standardise Common Radiological Protocols in General Radiography

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Background: Standardising clinical protocols across every piece of equipment is beneficial as part of the optimisation process. The aim of this study was to compare technical parameters from 4 common AEC based radiological protocols across 7 general radiography rooms.

Methods: Image quality of 4 different AEC based protocols were evaluated using a Leeds test tool (GS2) and varying levels of perspex depending on the protocol selected as shown in the figure 1 and 2. The technical parameters that were studied included Dose area product (DAP), exposure indices (EI), kV, mAs, default collimation, active AEC chambers, pre-set AEC dose and source to image distance (SID) for chest PA, abdomen AP, pelvis AP and lumbar spine AP investigations.

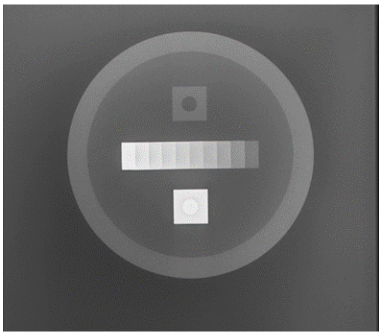

Figure 1: Grey scale from GS2 test tool is fully resolved.

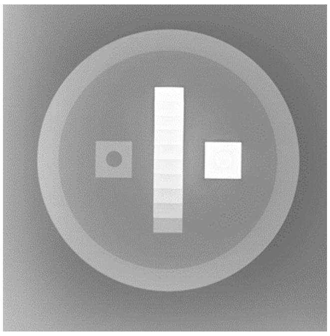

Figure 2: Grey scale from GS2 test tool is partially resolved.

Results and Discussion

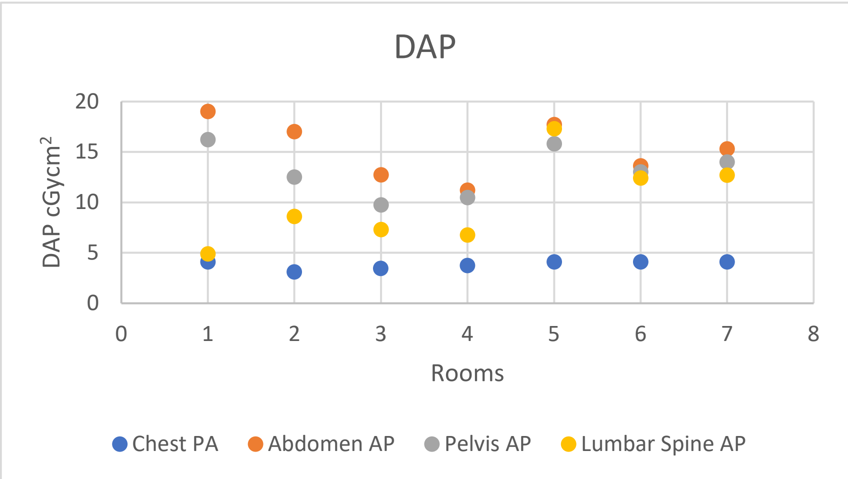

Figure 3: Distribution of DAP values for 4 different protocols in 7 rooms.

Figure 3 shows variations in DAP between the rooms for chest PA, abdomen AP, pelvis AP and lumbar Spine AP protocols. This is due to variations in default kV and inappropriate selection of AEC chambers between each equipment. We also found that for some of these default protocols the GS2 test tool was not fully resolved suggesting that for some of these protocols' optimisation of window width and center could to help achieve better image quality.

Conclusion: This is a preliminary study and the data gathered is useful to standardise clinical protocols or create tailored protocols for certain rooms depending on their usage. These results are also useful for comparing changes in protocols for future QA and when commissioning new units.