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Radiotherapy Physics
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GEC-ESTRO versus ICRU 38 dosimetry: the Co-60 perspective

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Purpose

The objective of this investigation was to explore the different methods of prescribing dose – ICRU 38 A points and GEC-ESTRO recommendations (Chassagne *et al* 1985, Pötter *et al* 2006 and Haie-Meder *et al* 2005)in the treatment of invasive cervical cancer with intracavitary brachytherapy techniques.
This is a treatment planning study of six patients treated with image guided brachytherapy (IGBT) using a Co-60 source. The dose to 2cm^3 of the organ (D_{2cc}) and ICRU point doses are compared as indicator of dose to organs at risk (OARs).
This study is designed to contribute to the required research on the use of Co-60 in the context of treatment planning and reporting parameters akin to the research that already exists for the use of Ir-192 for HDR brachytherapy (Tanderup *et al* 2010).
Portsmouth Oncology centre is the first department in the UK to use Co-60 for HDR brachytherapy (IBt-Bebig, HDR Multisource), having prior extensive experience of Ir-192 use.

Methods

6 patients received HDR brachytherapy following a course of external beam radiotherapy with a prescription dose (PD) 50.4Gy in 28 fractions. The brachytherapy was delivered in 2 fractions one week apart each fraction planned separately with PD of 17Gy in 2 fractions.
All patients were treated with a ring applicator and IUT, no interstitial needles were used. The patient treatments were CT planned using HDRPlus treatment planning system (IBt-Bebig, HDRPlus 2.5). The high risk clinical target volume (HRCTV), bladder, rectum and sigmoid were outlined on the CT by the radiation oncologist.

A Point Plan

All patient plans were prescribed to the ICRU 38 A points and OARs dose points were placed on the bladder and rectum in the transaxial plane. A loading pattern based on standard Manchester loading was used as the initial starting point for dose optimisation. The dose distribution was manually altered for each fraction to ensure A point prescription at 100% and where possible bladder and rectal doses less than 67% of the prescribed brachytherapy dose. GEC-ESTRO guidance was followed in the reporting of brachytherapy physical doses for HRCTV - V100%, V150%, D100, D90 and for bladder, rectum and sigmoid – D_{2cc}, D_{1cc} and $D_{0.1cc}$.

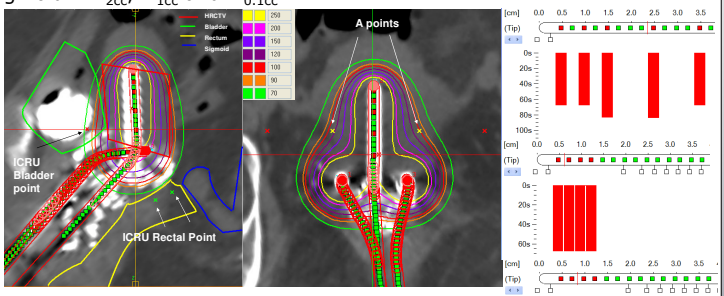

Fig 1. Orthogonal views of an optimised HDR plan using HDRPlus treatment planning system (IBt -Bebig). Isodose lines show percentage of prescribed dose.

Fig 2. A graphical representation of dwell positions and times used for an optimised plan. Standard loading and A point prescription were used as the initial starting point and manual optimisation was used to create a optimised plan. D90Gy =100%.

Optimised Plans

All 6 patients were then optimised for HRCTV prescription using a starting point of standard loading and A point prescription. Manual optimisation, adjusting the dwell times and using the DVH parameters as a guide, was used to optimise the dose to the HRCTV. A D90 of 100% of PD was achieved where OAR dose constraints would allow.
This method of optimisation was chosen over the use of the inverse planning approach as it gave real-time control of the dose distribution and only the necessary changes to the standard loading pattern were made.
OAR doses were recorded and biological equivalent dose calculations were used to report EQD_{2Gy} for the combination of the EBRT+Brachy for the tumour and the OARs.
Physical brachytherapy doses were assessed using key indicators including OAR sparing factors (D_{2cc}/D90) and ratio of ICRU A point dose to dose delivered to 2cc of the OAR (D_{ICRU}/D_{2cc}). The impact of organ volume was also assessed in achieving an optimised plan.
(Tanderup *et al* 2010)

Results

As expected coverage of the HRCTV improves when the plan is optimised to a D90 of 100% of PD rather than prescribing to the A points. The A point doses were a poor indicator for the dose delivered to the HRCTV with D90 47 – 95% of PD when the volume of the HRCTV is > the median volume of 60cc. Optimisation improved the D90 to 73 - 100% of PD with the A points at an average 110% of PD for all plans.

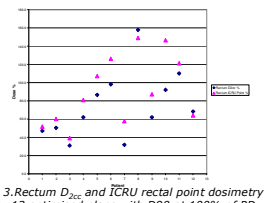

Fig 3.Rectum D_{2cc} and ICRU rectal point dosimetry for 12 optimised plans with D90 at 100% of PD

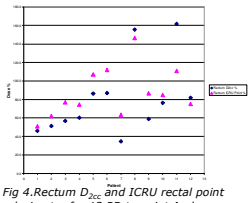

Fig 4.Rectum D_{2cc} and ICRU rectal point dosimetry for 12 PD to point A plans.

The D_{2cc} physical brachytherapy dose for the rectum is less than the ICRU rectal point dose for 10 of the 12 plans for the optimised plans (see Fig. 3) and A point plans (see Fig. 4). When A point prescription is abandoned and the PD is optimised to the HRCTV the magnitude of D_{2cc} rectum and the ICRU rectal dose point is reduced (see the sparing factor in table 1) this is dependant on the OAR size and position of the rectum with respect to the HRCTV.

Rectum	Volume	Sparing Factor D_{2cc}/D90	D_{ICRU}/D_{2cc}
A Point Plan	45cc±25cc	110±72	122±29
Optimised Plan		88±38	125±25

Table 1. Physical Parameters describing median rectal volume and dose for 12 patient plans

Bladder	Volume	Sparing Factor D_{2cc}/D90	D_{ICRU}/D_{2cc}
A Point Plan	78cc±16cc	117±32	82±25
Optimised Plan		97±21	72±25

Table 2. Physical Parameters describing median bladder volume and dose for 12 patient plans

The D_{2cc} for the bladder is greater than ICRU dose point for the bladder in 10 of the 12 plans (see fig. 5) this is due to the ICRU bladder point being a poor surrogate for bladder wall maximum dose. With the advent of IGBT the bladder can now be seen clearly on CT and the posterior edge of the bladder balloon is not representative of the bladder wall.

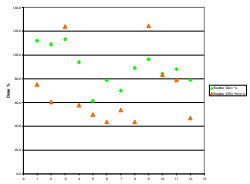

Fig 5.Bladder D2cc and ICRU bladder point dosimetry for 12 optimised plans with D90 at 100% of PD

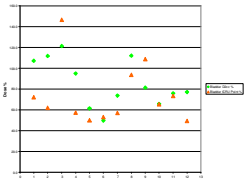

Fig 6.Bladder D2cc and ICRU bladder point dosimetry for 12 PD to point A plans

The EQD_{2Gy} D_{2cc} for the rectum illustrates a consistent difference with the ICRU rectal point. The volume and position of the rectum with respect to the HRCTV is crucial in maintaining the dose below constraints.
EQD_{2Gy} for D_{2cc} bladder and ICRU bladder point demonstrates a mismatch between the two reporting methods. D_{2cc} is greater than the ICRU bladder point due to the close proximity of the bladder wall to the HRCTV volume, as the dose is increased to the HRCTV it is also increased to the bladder D_{2cc} .
The EQD_{2Gy} D_{2cc} for the sigmoid remained very stable at approximately 50Gy and only deviated from this when the OAR volume increased dramatically from the median 17±11cc The sparing factor for the sigmoid was improved by 20% when an optimised plan was achieved.

Conclusions

This study has demonstrated a move from ICRU 38 to GEC-ESTRO based dosimetry is valid for Co-60 sources.
Co-60 behaves in a similar way to that of Ir-192 when prescribing to the HRCTV rather than the ICRU A points. The dose delivered to the OARs have the same relationship as predicted by Ir-192 studies (Tanderup *et al* 2010). More dose can be delivered to the HRCTV with improved knowledge of doses to the OARs. These results will help contribute to the clinical decision to improve the prescription used, and move from A point prescribing using Co-60 as an alternative to Ir-192.

References

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