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 2cm³ of the organ (D2cm³) 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 allowing for thorough 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 – D2cm³, D15cc and D5cc.

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 EQD20 for the combination of the EBRT+Broncy for the tumour and the OARs.

Physical brachytherapy doses were assessed using key indicators including OAR sparing factors (D2cm³/D90) and ratio of ICRU A point dose to dose delivered to 2cc of the OAR (Dicu/D2cm³). 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 D2cm³ and ICRU rectal point dosimetry for 12 optimised plans with D90 at 100% of PD

The D2cm³ 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 abandoed and the PD is optimised to the HRCTV the magnitude of D2cm³ and the ICRU rectal dose point is reduced (see the spacing factor in Table 1) this is dependant on the OAR size and position of the rectum with respect to the HRCTV.

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

<table>
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<th>Parameter</th>
<th>Median</th>
<th>25%</th>
<th>75%</th>
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<tbody>
<tr>
<td>D2cm³</td>
<td>96.8Gy</td>
<td>92.7Gy</td>
<td>97.2Gy</td>
</tr>
<tr>
<td>ICRU D</td>
<td>61.1Gy</td>
<td>57.5Gy</td>
<td>63.0Gy</td>
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Table 2. Physical Parameters describing median bladder volume and dose for 12 patient plans

<table>
<thead>
<tr>
<th>Parameter</th>
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<tr>
<td>ICRU D</td>
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The D2cm³ 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 in a poor surronding for bladder wall. 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 D2cm³ and ICRU bladder point dosimetry for 12 optimised plans with D90 at 100% of PD

The EQD20 for D2cm³ and ICRU bladder point demonstrates a mismatch between the two reporting methods. D2cm³ 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 D2cm³.

The EQD20 for the sigmoid remained 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.

For Further Information on this work please contact: napton@portsmouth.nhs.uk

Presentation of this work has been kindly supported by Ibt-Bebig and SeenDDS Ltd.