Portsmouth Hospitals NHS
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Does the choice of isotope, Co-60 or Ir-192, effect treatment planning techniques and outcomes for high dose rate (HDR) brachytherapy?

Palmer A, Mzenda B, Hayman O, Nagar Y
Queen Alexandra Hospital, Portsmouth Hospitals NHS Trust, UK

Objective

The long half-life of Co-60 compared to Ir-192 has economic and practical benefits, however the effect of the higher energy of Co-60 on treatment planning approaches and outcomes in gynaecological HDR brachytherapy has not been fully investigated.

This work compares the physical source characteristics of the two isotopes used in the IBt Bebig MultiSource® afterloading system, and investigates differences in planning techniques to optimise tumour coverage and critical organ (OAR) sparing for the two isotopes.

Method

The high risk clinical target volume (HR-CTV), bladder, rectum and sigmoid were outlined on CT images of eight gynaecological patients for HDR brachytherapy. Several 3D treatment plans were produced for each patient on the HDRplus® treatment planning system (TPS), using an intra-uterine tube (IUT) and ring applicator, with 1:1 IUT/ring standard loading. The planning variables used in this study were:

- The choice of isotope, Co-60 or Ir-192;
- The choice of dose prescribing and normalisation (to Manchester point A or GEC-ESTRO HR-CTV);
- Standard and non-standard loading patterns;
- TPS algorithm dwell-time optimisation.

Quantitative analysis of the resulting treatment plans was performed using isodose distributions, dose volume histograms, HR-CTV D90 and V100%, doses to point A, ICRU rectum and bladder, and D0.1cc, D1cc and D2cc for the OARs.

Monte Carlo data was used to determine the dose differences from Co-60 and Ir-192 sources resulting from anisotropy, radial dose and geometric effects, and explain the differences found in the clinical plans.

Results

Figure 1 shows the differences in dose distribution between Co-60 and Ir-192, in three planes, for a typical HDR gynaecological patient plan. Figures 2 and 3 show the significant affect of different 'loading patterns' and different prescribing methods on the dose differences between the two sources, for the patient in Figure 1. Figure 4 shows the consistency of differential dose patterns for four other patients. The colour-wash is optimised to show +2% to -2% only, covering the majority of clinically relevant regions on the images.

Table 1 provides the differences in dosimetric quality indices for Co-60 compared to Ir-192, based on GEC-ESTRO (2005) and ICRU 38 (1985) reporting parameters.

In general, Co-60 delivers higher doses within the HR-CTV and lower doses to the organs at risk, except along the extension of the source axis: most clearly seen as elongated higher dose regions in the sagittal view. Evaluation of doses to OARs across the range of treatment plans showed that the choice of prescription technique and the optimisation parameters used were more significant than the physical differences between the two isotopes, with HR-CTV D90 being near-identical in all cases.

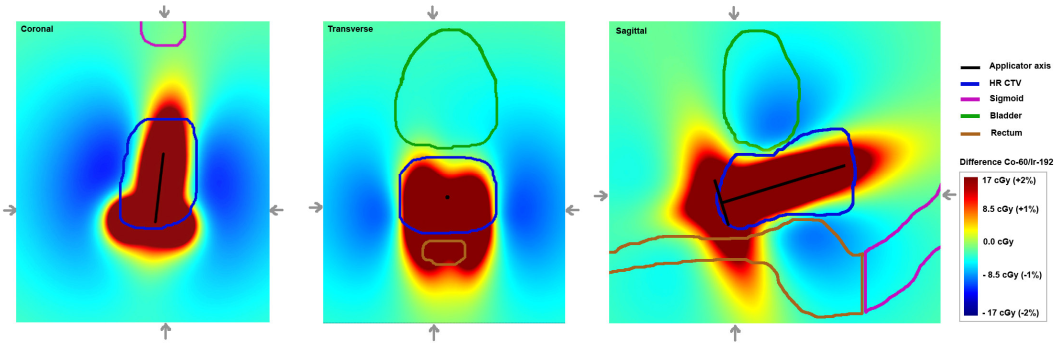

Fig 1. Percentage difference in dose distribution between Co-60 and Ir-192 sources with the IBt-Bebig HDR MultiSource® brachytherapy unit, in coronal, transverse and sagittal planes, for a typical 3 channel gynaecological treatment prescribed to ICRU Point A. Colour wash shows the +2% to -2% differences. The applicator axes and outlines of the HR-CTV and OARs are shown.

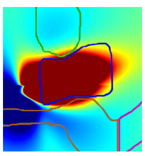

Fig 2. Percentage difference in dose distribution between non-standard dwell position loading for Co-60, to minimise rectal dose, compared to conventional loading for Ir-192, both prescribed to ICRU Point A

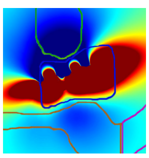

Fig 3. Percentage difference in dose distribution between Co-60 and Ir-192 when prescribed to HR-CTV using high-penalty rectal and bladder constraints

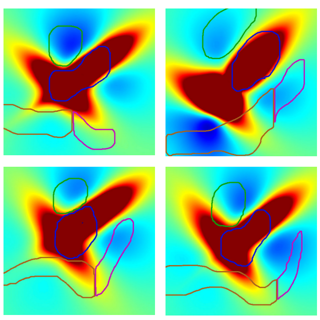

Fig 4. Percentage difference in dose distribution between Co-60 and Ir-192 for four different gynaecological HDR patients prescribed to ICRU Point A, showing consistency in dose differences between the two sources, and variability in OAR geometry

Table 1. Percentage difference in GEC-ESTRO and ICRU dose reporting indices between treatment plans created with Co-60 and Ir-192 sources. Mean and standard deviation results are presented for a consecutive series of 8 clinical treatment plans prescribed to ICRU Point A and then to HR-CTV. Results of modified loading for Co-60, to reduce rectal dose, compared to conventional loading with Ir-192, prescribed to Point A, are also presented.

% differences of Co-60 compared to Ir-192 plans	Bladder D2cm^3	Rectum D2cm^3	Sigmoid D2cm^3	HR-CTV		ICRU reference points			
				V100%	D90Gy	A-point (R)	A-point (L)	Rectum	Bladder
Plans prescribed to Point A using 'standard loading patterns':									
mean over 8 patients	-0.9	3.8	-1.4	1.8	0.0	0.3	0.1	3.5	2.1
standard deviation	5.5	2.2	3.5	2.3	3.0	2.7	1.6	4.1	4.0
Plans prescribed to HR-CTV using optimised inverse planning techniques:									
mean over 8 patients	-0.4	0.9	-0.3	0.7	-0.2	-0.1	-0.4	2.4	0.1
standard deviation	2.6	3.3	3.5	1.4	2.0	3.3	2.5	2.8	2.9
Plans prescribed to Point A comparing two 'modified loading patterns' for Co-60 compared to 'standard loading pattern' for Ir-192:									
reduced no. Co-60 dwells in ring	1.3	-1.1	-4.5	0.0	-5.2	4.3	-3.8	4.1	0.0
reduced no. Co-60 dwells in ring & IUT	5.3	-9.7	0.0	3.2	0.0	4.3	-3.8	-12.2	1.5

Conclusion

This work has shown that the dose prescribing method and source 'loading patterns' are more significant to the final dose distribution than the choice of isotope for HDR gynaecological brachytherapy.

The physical differences in dose distribution around the IBt-Bebig Co-60 and Ir-192 sources have a negligible effect on the resulting clinical treatment plan quality parameters, especially when dwell optimisation via inverse planning techniques is used. However, Co-60 will deliver higher doses than Ir-192 along the extension of the IUT due to anisotropy differences, > 10% at 5cm distal to the applicator.

Significant cost savings may be achieved with Co-60 since source replacements are required every 4-5 years compared to Ir-192 where new sources are needed every 3-4 months. Equipment down-time and physics support time is also reduced by around 40% with Co-60 in comparison to Ir-192.

Over 60 treatments have now been performed using the IBt-Bebig HDR Multisource at Portsmouth, UK; approximately half of these were treated with an Ir-192 source before moving to a Co60 source.

Fig 5. The IBt-Bebig HDR MultiSource® brachytherapy unit

Further information may be obtained from Tony Palmer: antony.palmer@porthosp.nhs.uk
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