A novel integrated measure of cervical HDR brachytherapy plan quality

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Background

- Brachytherapy is an integral part in the treatment of cervical cancer
- The use of intra-cavitary +/- interstitial applicators allows the delivery of a tumoricidal dose, aiming for a D90 to the high risk CTV (HRCTV) of > 85Gy
- This has to be balanced with the published constraints for the surrounding organs at risk (OARs) which include the rectum, sigmoid, small bowel and bladder
- Often multiple plans are generated per fraction whilst trying to achieve this balance - to maintain the dose to HRCTV whilst minimising the dose to the OARs
- The 5 main clinical variables for each plan that are used to decide on the quality of the plan consist of:
  - D90 HRCTV
  - d2cc rectum
  - d2cc sigmoid
  - d2cc small bowel
  - d2cc bladder
- However it can be difficult to quantify how good each plan is and to rank them accordingly

Aims

We propose the use of an n-dimensional vector to derive a **single value (z)** from these 5 variables to help quantify objectively the quality of an HDR cervical brachytherapy plan.

Methods

- The HDR plans for a consecutive cohort of cervical cancer patients were reviewed
- The dosimetry of the combined EBRT (45Gy in 25#s) and HDR brachytherapy doses for each was assessed in terms of the planning targets of:
  - D90 HRCTV ≥ 85Gy
  - d2cc bladder < 80Gy
  - d2cc rectum /sigmoid/ small bowel < 65Gy
- Based on the doses to these 5 variable the patient cohort was split into 3 groups:
  - **Group A** - d90 HRCTV ≥ 85Gy and OARs all within constraints
  - **Group B** - d90 HRCTV ≥ 85Gy and one or more of the OARs exceeded constraints
  - **Group C** - d90 HRCT < 85Gy regardless of the OARs

Methods continued

- The vector calculated has n components (x_1, …, x_n) which were all equally weighted and were made up of :
  - d2cc values for bladder, rectum, sigmoid and small bowel (lower values indicating a lower dose to the OARs)
  - for the HRCTV component we used (135 - d90), so for higher (and more favourable) radiation doses to the tumour we get a lower component value, equivalent to a low d2cc value
- The magnitude of the vector was calculated:

$$z = \sqrt{x_1^2 + \cdots + x_n^2}$$

- We hypothesised that better plans should have smaller z value indicating that the targets were being met more optimally
- Statistical testing for differences amongst the 3 groups was carried out using the Kruskal-Wallis test with significance taken a p<0.05

Results

- Records for 112 consecutive patients were reviewed and assigned to one of the 3 groups and the n-dimensional vector z values was calculated for each

	Group A	Group B	Group C
Number of cases	27	53	32
Mean z	128.22	134.85	141.78
Median z (range)	126.94 (117.45 – 139.57)	134.72 (125.54 – 146.37)	142.05 (133.17 – 155.53)
Standard deviation	5.24	4.19	5.39

- There was a significant difference for the z value among the 3 groups: Kruskal-Wallis H statistic = 59.87, p < 0.0001 (df=2)

Conclusions

- The z value was significantly different among plans achieving the planning constraints to different degrees
- It can help objectively quantify the quality of the brachytherapy plans and could help inform the choice between plans with variations in doses to the different OARs

References

1. Recommendations from (GYN) GEC-ESTRO Working Group (I); Radiotherapy and Oncology 74 (2005) 235–245.
2. Recommendations from (GYN) GEC ESTRO working group (II): Radiotherapy and Oncology 78 (2006) 67–773