Second Cancer Risk after Radiation of Localized Prostate Cancer with and without Flattening Filter

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Purpose

Radiotherapy is a standard treatment modality with curative intent for localized prostate cancer. Prostate cancer is a disease of elderly men. Nevertheless these patients have a remaining life span of ten years or more. Radiotherapy compared to surgery may increase the risk for second cancer [1]. Minimizing this risk can be one criterion in deciding for a specific technique. Therefore we compared the organ equivalent dose (OED) and excess absolute risk (EAR) for second cancer for different treatment techniques.

Material and methods

For ten patients four different plans were calculated, using a seven field intensity modulated radiotherapy (IMRT) and a single arc volumetric modulated arc therapy (VMAT) with and without flattening filter. The optimization was performed as simultaneous integrated boost in 33 fractions, aiming for 59.4 Gy minimum dose to the PTV and 71.0 Gy minimum dose and 74.2 Gy maximum dose to the CTV. The objectives for the optimization were based on an earlier investigation [2]. The OED was computed for the urinary bladder and the rectum from dose volume histograms for the linear-exponential and the plateau dose-response model [3]. The EAR can be derived from the OED, taking age modifying parameters into account. The statistical analysis was performed using the Wilcoxon test in IBM® SPSS® Statistics 23 (IBM Corporation). Murray et al. have performed a similar investigation [4] on three patient data sets. However, differences in the dosage, the treatment technique, the number of patients and another TPS might have impact on the results. Choosing ten patients we intended to get results with statistical significance.

Results

Within one technique (IMRT or VMAT) the average value of the OED is lower for the flattening filter free (FFF) mode compared to flat beams (FB) in both organs and for both dose-response models with one exception: In the urinary bladder it is the other way round for IMRT and the linear-exponential model. These results are statistically significant (level of significance 5%). The results for VMAT are statistically significant for the rectum only in both models.
Comparing IMRT and VMAT the results are ambiguous: For the linear-exponential model the OED is lower with IMRT for both FB and FFF, for the plateau model lower OEDs are achieved with VMAT. All results are significant, except of one (lin-exp. model, FFF, urinary bladder, p = 7.4%).
The average values for the EAR for patients of 71 years at exposure and an attained age of 84 years are given in table 1.

Discussion and conclusion

Some statistically significant differences have been found for the different treatment techniques and modes. However, they depend on the dose-response model. For the plateau model the lowest EAR is found for VMAT FFF in both organs at risk, for the linear-exponential model IMRT FB shows the minimum values. Plan quality and efficiency should additionally be regarded before the decision for a specific technique and mode [5]. Although we found the absolute values of the EAR quite different to Murray et al [4], in the comparison of FFF and FB the EAR differs (with one exception) less than 2%, similarly.

	Urinary Bladder		Rectum	
	$EAR_{lin\text{-}exp}$	$EAR_{plateau}$	$EAR_{lin\text{-}exp}$	$EAR_{plateau}$
IMRT FB	41.66 ± 4.12	49.35 ± 6.04	1.19 ± 0.08	1.41 ± 0.11
IMRT FFF	43.53 ± 5.23	48.93 ± 6.42	1.21 ± 0.09	1.40 ± 0.12
VMAT FB	45.23 ± 5.49	48.33 ± 6.38	1.26 ± 0.09	1.40 ± 0.11
VMAT FFF	44.68 ± 6.17	47.98 ± 6.92	1.24 ± 0.09	1.39 ± 0.12

Table 1. Excess average risk in 10,000 person years

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