Effects of intensity modulated radiotherapy (IMRT) on prostate volume – Comparison of 39 patients before and after radiotherapy

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Introduction

It is known that during the course of androgen deprivation therapy (ADT) for treatment of prostate cancer or benign hyperplasia, the prostate gland shrinks by 20–50% [1]. The maximum shrinking effect occurs during the first 3 months of ADT wich coincides with the period between simulation and end of a typical radiotherapy. Therefore ADT should be started 2-3 months before radiotherapy [2]. If a radiotherapy is applied simultaneously to ADT, a significant reduction of the prostate gland may occur during the course of combined ADT+RT or in response to radiotherapy after termination of ADT [3]. The volume decrease is critical since a displacement of surrounding organs (e.g., rectum and bladder) into the radiation field can cause radiation-induced side effects. We quantified the volume reductions for patients with and without ADT undergoing high precision intensity modulated radiation therapy (IMRT).

Material and methods

Thirty-nine patients undergoing IMRT were enrolled (median age 68.7 years; range 47–80). All patients had biopsy-proven prostate carcinoma (T1c-3) without regional nodes or distant metastases (N/M0-x). All patients underwent inversely planned, "step-and-shoot"-IMRT with a photon energy of 6 MeV (median total doses 76 Gy; 38 fractions). Median duration of IMRT was 54 days (range 27 to 71 days). 22 patients with ADT prior to IMRT (median duration 5 months; range 1–24) were compared with 17 patients with RT alone. The median delay between diagnostic simulation MRI and the initiation of the IMRT was 30 days (range: 9–70 days). T2 weighted TSE images in three orthogonal planes were acquired (1.5T Magnetom; Siemens, Erlangen, Germany; axial/coronal/sagittal TR 4946/4700/4450 ms, TE 120/120/120 ms, 1024x140 / 1024x330 / 1024x420 matrix, 3 mm slice thickness without gap, FOV 140). All follow-up MRI exams were performed with the same technique. In consensus two readers defined the largest diameter of the prostate on each data set in axial and sagittal slices (Fig. 1). Prostate gland volume was calculated using the ellipsoid formula: volume = 0.56 x height x width x length cm^3. Percentual volume reduction was calculated. Means were compared and confidence intervals were calculated per examination time using a linear mixed model (SAS 9.1 SAS Institute Inc., Cary, NC, USA).

Fig. 1: Patient without ADT before (upper row) and after IMRT (bottom row) showing the measurement for volume analysis.

Results and discussion

The median interval between planning MRI and 1st follow-up was 133 days (range 104–260). The 2nd MRI was performed after 232 days (range 188–494), the 3rd after 443 days (range 400–813). The overall median interval was 233 days (range 126–813). Patients without ADT had a significantly larger prostate volume (Fig. 2). Mean volumes at planning MRI for non-ADT and ADT were 43.1ml vs. 22.8ml. In the 1st follow-up this volume difference was still present. While the non-ADT group showed a reduction of 20.3%, the ADT group showed a reduction of 16.8%. The percentage of volume reduction determined in the 2nd and 3rd follow-up was smaller (Tab. 1). Nevertheless, the volume difference was still significantly different at t_2 (p=0.0136). Patients with ADT had a 10.4% overall volume reduction, patients without ADT had -31.8%. Taken together, the reduction was 17.1%.

When evaluating ADT, examination time, and interaction between both factors using a linear mixed model, ADT and the examination time alone had a significant effect (p<0.0001). The combination of ADT and examination time showed a trend towards significance (p=0.0527).

	t_0	t_1	t_2	t_3
□ non-ADT	41,3	32,9	32,2	28,2
■ ADT	22,8	19,0	20,6	20,4

Fig. 2: Prostate volumes (in ml) with and without ADT as a function of time.

	t_0	t_1	t_2	t_3	Overall shrinkage
Non-ADT	41.3 ±18.3 ml	32.9 ±12.4 ml (-20.3%)	32.2 ±13.5 ml (-2.3%)	28.2 ±9.5 ml (-12.4%)	11.9 ±6.6 ml (-31.8%)*
ADT	22.8 ±10.5 ml	19.0 ±10.2 ml (-16.8%)	20.6 ±10.8 ml (8.5%)	20.4 ±4.3 ml (-0.7%)	3.6 ±6.4 ml (-10.4%)*
All	30.9 ±17.0 ml	25.1 ± 13.1 ml (-18.8%)	26.6 ±13.4 ml (6.0%)	25.6 ±8.7 ml (-3.6%)	6.2 ±6.5 ml (-17.1%)*
n all (non-ADT/ADT)	39 (17/22)	39 (17/22)	31 (16/15)	9 (6/3)	
Significance	p = 0.0007 CI 95% -27.4 to -9.1	p = 0.0005 CI 95% -21.3 to -6.6	p = 0.0136 CI95% -20.6 to -2.6	n.s.	

Table 1: Mean prostate gland volume (ml ± standard deviation) before IMRT (t_0) and at follow-up after IMRT (t_1-t_3) with percentage of volume reduction in parenthesis. *calculated directly from interindividual non-rounded data, therefore it is not possible to calculate these from the preceeding columns

Conclusions

The data shows that IMRT as well as IMRT+ADT have a significant shrinking effect on prostate volume. Although we can not distinguish from our data if this shrinkage effect occured during radiation therapy or occurred in the few months afterwards, our data is in the same range of volume reduction as those measured during radiotherapy [4]. Nevertheless, the effect is larger for those patients who undergo IMRT alone. This should be considered in planning IMRT to minimize extraprostatic radiation.

References: 1. Pilepich MV et al. *J Clin Oncol* 1997;15:1013-1021. 2. Sanguineti G et al. *Radiother Oncol* 2003;66:151-157. 3. Saitoh M et al. *Urology* 1994;43:342-348. 4. Roeske JC 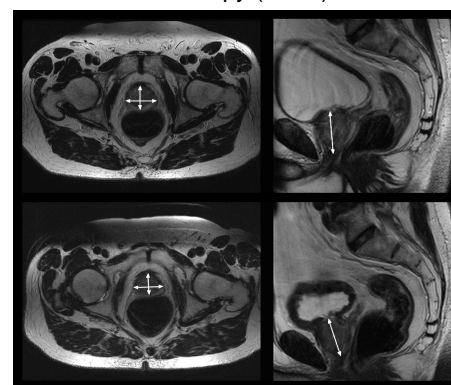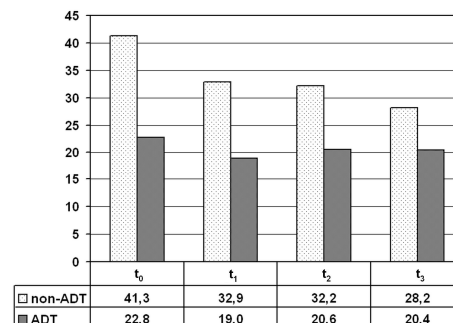et al. *IntJRadiatOncolBiolPhys* 1995;33:1321-1329.