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Prostate radiotherapy

Motion and shape change when using an endorectal balloon during prostate radiation therapy

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Abstract

***Purpose*: To investigate motion and shape change when using an endorectal balloon (ERB) in patients receiving radiotherapy for prostate cancer.**

***Methods*: In nine patients treated for prostate cancer using an ERB, the anterior wall of the ERB was contoured on right lateral images taken immediately before irradiation, and on left lateral images taken immediately after irradiation. Changes in the contours were used to calculate inter-fraction shape change and inter-imaging motion and shape change. Inter-imaging motion describes changes that occur after the right lateral image is taken that are seen in the left lateral image.**

***Results*: Eighty-six percent of all inter-imaging shifts of the anterior wall of the ERB were in the posterior direction (mean: 1.8 mm, 1 SD: 1.8 mm, maximum posterior shift: 2.8–7.2 mm). The inter-fraction shape change (1 SD) of the anterior wall was equivalent to a change in the angle of the balloon of 2.5–5.7°, with a range of 8–20°, depending on the patient. Inter-imaging shape changes were similar in size.**

***Conclusions*: The inter-imaging motion and shape changes may be explained by the patient relaxing some time after insertion of the ERB, indicating that it could be reduced by a waiting period after insertion before irradiation. Development of image-guided localization strategies should consider intra-fraction motion and also inter- and intra-fraction shape change.**
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A number of studies have shown that prostate-specific antigen (PSA) failure-free survival can be improved if the dose to the prostate gland is escalated beyond conventional doses of 70Gy [10,11,16,21]. Dose escalation is constrained, however, by the volume of the anterior rectal wall that receives greater than 70Gy, a level that is correlated with the severity of rectal toxicity [18]. In order to avoid significant toxicity when treating prostate cancer with escalated doses, most radiation treatment centers use a reduced posterior margin, but the extent to which this margin can be reduced is limited by inter- and intra-fraction motion of the prostate. Inter- and intra-fraction shape change may also be important, and are often neglected. Too small margins may result in lower doses to the posterior aspect of the prostate gland where most prostate cancers are located. It is therefore very important to understand all motion, including shape change, when deciding on treatment margins, and developing treatment strategies, including adaptive radiation therapy techniques which account for patient-specific details of motion and shape change.

Image-guided localization of the prostate can be used to reduce the impact of inter-fraction motion. In these techniques, the patient is first positioned on the treatment couch, and the position of the prostate detected using ultrasound [13,14], portal-imaging of radiopaque markers [1,2], or in-room CT [4,6], and the patient position adjusted to correct for inter-fraction prostate motion. These techniques do correct for inter-fraction motion but do not typically correct for inter-fraction shape change (which has been shown to be significant for some patients [5]), or for any intra-fraction changes. Typically, any motion not accounted for in the margins or image-guided patient positioning strategy can be expected to result in underdosing of the targets.

The use of an endorectal balloon has been investigated for gland immobilization [3,8,15,19,20]. Van Lin et al. [19] previously showed that the ERB does not significantly reduce inter-fraction motion, so image-guided localization is still needed. In addition to the techniques listed above, image-guided localization can be achieved by using the balloon as seen in mega-voltage portal images to localize the anterior wall of the rectum, and to position the patient so the treatment volume is anterior of this. The use of an ERB has several potential advantages [3,8,15,19,20]. It has been

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shown to reduce intra-fraction motion of the prostate [8]; the ERB pushes parts of the rectal wall away from the prostate, reducing rectal toxicity [15]; the use of an ERB has been shown to improve daily online correction using portal images [3]. It can also be expected that the use of an ERB may reduce inter- and intra-fraction shape change.

The goal of this investigation was to evaluate motion and shape changes of the ERB in a real treatment setting. This includes inter-fraction shape changes and also inter-imaging changes. We use the term inter-imaging changes to describe the changes after a pre-treatment is taken, and before a post-treatment image is taken. This is in contrast to intra-fraction changes, to emphasize the fact that our results cannot distinguish between changes due to initial relaxation after the balloon is first inserted (and the first image taken) but before the beam is turned on, and changes during 'beam-on' (true intra-fraction changes). Previous data indicate that actual intra-fraction changes are small [8]. Here we focus on the issue of shape change of the ERB. The additional information provided by this study will improve our understanding of shape change when using an ERB in a real treatment setting.

Methods and materials

This investigation used portal images from nine patients enrolled in a study approved by the Institutional Review Board of Brigham and Women's Hospital. In this study, an endorectal balloon is used to immobilize the prostate for the first 15 radiation therapy fractions. The patient is positioned supine, using a standard foam leg immobilization device (AliMed, Inc., Dedham, MA). The balloon is inserted into the rectum, using marks on the shaft to control the amount of insertion (consistency better than 5 mm) and also to prevent unwanted roll. The balloon is then inflated with 60 cc of air. A right-lateral portal image is taken using film (see Fig. 1), and visually compared by the radiation therapy therapists with the plan digitally reconstructed radiograph (DRR). A vertical (anterior–posterior) couch-shift is made if necessary. The patient is then treated using 4-field three-dimensional conformal radiation therapy. Immediately after the treatment a left-lateral portal image is taken. A left lateral was taken, rather than a repeat lateral, so that the additional imaging did not significantly impact patient treatment time (as would have been the case if additional gantry rotation was needed). These images are taken for all fractions for which the ERB is used. The mean time between the left and right lateral images is 10 min (range: 8–12 min). Specific details regarding the plan and correction strategy are not important – the important fact is that this study provides us with a series of pre- and post-treatment lateral images that can be used to compare the position and shape of the rectal balloon. Examples of the right and left lateral portal images for one fraction of one patient are shown in Fig. 1.

The lateral portal films were scanned using a film scanner (Dosimetry-PRO, Vidar Systems Corp., Hendon, VA), and imported into image display and contouring software written specifically for this project. Small variations in magnification and orientation were corrected by calibrating each digital image using the graticule seen in the image. The anterior wall of the balloon was contoured for each lateral image (see Fig. 1 for an example). This was repeated 2–3 weeks later for 28 images in order to evaluate intra-user contouring variability. A second observer reviewed all contoured images.

The couch shifts that the therapists made based on the right-lateral portal image were collected using the difference between the vertical couch position for the portal image and that for the first treatment beam, as recorded by the record-and-verify software (IMPAC, Mountain View, CA).

The AP coordinate of the anterior wall of the balloon at the time of the first image was calculated by shifting the contour of the right-lateral image by the couch shift that was made after the image was taken. The inter-imaging change in the anterior wall of the balloon was calculated by subtracting the AP coordinate of the contour form the left-lateral image from the corrected right-lateral coordinate. Inter-imaging motion was calculated as the mean change in the AP coordinate of the central 2 cm of the balloon contour. This mean value was used as an indication of the average movement, neglecting shape change. The standard deviations of the systematic and random errors were calculated (as in references [17,9]).

Inter-fraction shape change was calculated by normalizing the contours in the left-lateral images at isocenter, and calculating the standard deviation and range of the AP

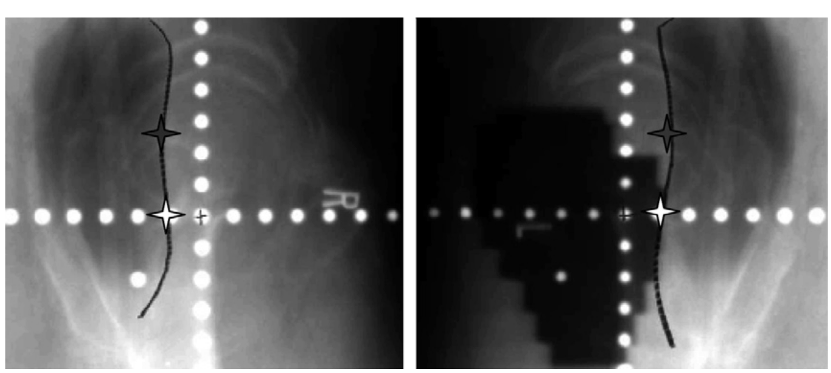

Fig. 1. Right and left lateral portal images, with the anterior wall of the balloon marked. The left lateral portal image also shows the treatment portal. The point used to normalize the data when evaluating inter-imaging shape change is shown by the white cross. The point used to compare shape change is shown by the black cross.

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