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Evaluation of IGRT techniques in prostate cancer patients with registration of bony anatomy and implanted gold markers

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Introduction

Our IGRT protocol for external beam radiotherapy for low and intermediate-risk prostate cancer patients requires registration of internal fiducial gold markers implanted in the prostate. On the other hand, registration of images of the setup fields at high-risk prostate cancer patients are based on bony structures without using gold markers, which might require larger margin for the prostate. The aim of this study is to determine the accurate CTV-PTV margin of the prostate for patients treated without gold markers.

Methodology

In this retrospective study, 10 low and intermediate-risk prostate cancer patients with 3 implanted internal fiducial gold markers were selected for evaluation. Varian TrueBeam linear accelerator was used for the treatments and the patient position verifications were based on a kV-kV image pair before each fraction. In agreement with our protocol, either simultaneously integrated boost or traditional sequential irradiation technique was applied, thus 28-39 sets of image pairs were registered for each patient. The patients were treated after online matching using the gold markers. Varian Offline Review option was used by two independent observers with manual matching in 3 directions on two perpendicular images according to bony anatomy (Figure1). Vertical (VERT), longitudinal (LONG) and lateral (LAT) differences between the online and offline matched positions were calculated. Differences between skin-marked setup position and online corrected position were also read out in order to calculate margins if daily image guidance is not available. According to the van Herk equation, standard deviations of the systematic and random treatment set-up errors for all patients in all three directions were calculated. Finally, CTV-PTV margins for prostate were determined for the two scenarios. We investigated if the overall mean population errors are greater than the standard deviation of the errors.

Results

On average, 31 sets of kV image pairs were involved in the study. In case of daily image guidance, the systematic set-up errors were found 3 mm, 2 mm and 1 mm and the population inter-fraction random errors were 2 mm, 2 mm and 1 mm in VERT, LONG and LAT directions, respectively. The overall mean systematic errors for all patients were 0.1 mm, 0.4 mm and 0.1 mm in VERT, LONG and LAT directions, respectively. Without image guidance, the systematic and inter-fraction random errors were 4 mm, 4 mm, 2 mm and 5 mm, 3 mm, 2 mm in VERT, LONG and LAT directions, respectively. For this scenario, the overall mean systematic errors were 1 mm in VERT direction and 0 in the other two directions. These values resulted in 9 mm, 7 mm, 3 mm and 11 mm, 12 mm, 7 mm margins for the prostate in VERT, LONG and LAT directions if daily image guidance is applied or not, respectively. Currently, our clinical protocol requires 8 mm and 10 mm uniform margin in case of the above mentioned two scenarios. The standard deviation of the sampling distribution in each direction was determined and no statistically significant systematic errors were detected.

Conclusion

The results show that applying daily image guidance and matching the image sets according to bony structures without internal fiducials could reduce the margin with 2 mm, 5 mm and 4 mm in VERT, LONG and LAT directions. Besides, if internal fiducials are applicable and daily image guidance is available, on average an additional uniform 3 mm margin reduction is applicable. The overall mean systematic errors do not indi-

cate any large inaccuracy in our set-up procedure, however further investigation with larger population is recommended for statistically stronger results.

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