Comparison of bone alignment and fiducial marker alignment for online cone-beam computed tomography-guided radiation therapy for prostate cancer

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Objective

The aim of the study was to evaluate the coverage of the prostate when prostatic implanted fiducial markers are used to verify setup of the patients in comparison to the pelvic bones while using cone-beam computed tomography (CBCT).

Methods

Seventeen patients with prostate cancer were included. For each patient, daily online CBCT was done. CT planning was matched with CBCT with the help of fiducial markers (3-5 markers) and another matching with done the help of pelvic bony landmarks. Registration of CTV1 including prostate plus seminal vesicles and CTV2 including prostate only was done and were used to confirm the target volume during the process of matching. Delineation of the rectum on every CBCT was done. Two automatic margin representing PTV were created. PTV1 was generated by adding 1 cm in all directions (PTV1a) and 0.7 cm in the posterior direction (PTV1b). PTV2 was generated by adding 0.5cm in all directions (PTV2a) and 0.3cm in the posterior direction (PTV2b). PTV1a was prescribed to receive 46 Gy in conventional fractionation with a boost dose of 30 Gy to PTV1b. The same dose was prescribed to PTV2a and PTV2b. Calculation of the percentage of intersection between CTV1 and CTV2 created on CBCT with the original CTV scan was done. A comparison between the two CTVs (CTV1 and CTV2) mean dose and the original delineated CTV was done. Then a comparison to the mean dose of the original CTV of PTV1a, PTV2a (CTV1a and CTV2a), and for PTV1b and PTV2b (CTV1b and CTV2b). Calculation of the mean rectal dose and also V60, V70 and V74 was done on the delineated rectum on every CBCT, and then a comparison to the planned original rectal dose.

Results

The created CTV1 and CTV2 intersection percentage with the original CTV1 and CTV2 significantly increased by 85% (range, 65%-95%, $p < 0.05$), when fiducial markers were used. The main difference of the received mean dose was significantly less in comparison to pelvic bone alignment. (0.03 to 2% vs 0.03 to 11.6% for PTV1a, $p<0.006$, 0.01% to 1.8% vs 0.03 to 10.2% for PTV2a $p<0.014$, 0.08 to 2.11 vs 0.04 to 11.29 for PTV1b, $p<0.015$ and 0.01 to 1.79 vs 0.01 to 9.69 for PTV2b, $p< 0.004$). With the use of less PTV margins , significant decrease of the rectal mean dose, V60, V70 and V74 by $p <0.004$, $p<0.004$, $p<0.0005$ and $p<0.009$, respectively. Reduction of the CTV1a and CTV1b mean dose by 1.13% and 0.28% in comparison to the initial CTV1a and CTV2a.

Conclusion

A significant improvement of prostatic cancer patients alignment when fiducial markers are used, with more homogenous dose distribution, and with significant decrease in PTV margins. The delivered rectal dose is significantly less allowing prostate dose escalation.