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Comparison of volumetric-modulated arc therapy and intensity-modulated radiation therapy prostate cancer plans accounting for cold spots

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論 文 名: Comparison of volumetric-modulated arc therapy and intensity-modulated radiation therapy prostate cancer plans accounting for cold spots
(前立腺癌治療計画におけるＩＭＲＴとＶＭＡＴのコールドスポットの比較)

区　　分：甲

論　文　内　容　の　要　旨

There has been a significant increase in the number of prostate cancer patients treated with volumetric-modulated arc therapy (VMAT) and intensity-modulated radiation therapy (IMRT) in Japan because of their lower risks of urinary and sexual dysfunctions. However, in VMAT and IMRT treatment plans, there are trade-offs in target coverage and OAR dose-sparing, which result in routine encountering of high dose (hot spots) and low dose (cold spots) regions in the planning target volume (PTV). Small volumes of low dose regions (cold spots) in the target volume in prostate cancer treatment could lead to a reduction of the tumor control probability, which would cause recurrence of tumors. In order to focus on tumor control, we deal with cold spots in this study. Additionally, the region in which the rectum overlapped with the PTV along the anterior wall is defined as the rectum-overlap PTV (ROP) region. The cold spots in ROP regions may be associated with recurrences of tumors. Therefore, the investigation of cold spots in the ROP regions is necessary to understand how the magnitude, volume, and distribution of these low dose regions in VMAT and IMRT plans.

The goal of this study is to compare VMAT with IMRT accounting for cold spots in prostate cancer plans. The basic idea was to evaluate dosimetric indices for the PTV and organs at risk (OAR) including the rectum, bladder, right and left femoral heads, and ROP regions , and to analyze (numbers and volumes) and visualize cold spots in the PTV and ROP regions for VMAT and IMRT plans. Firstly, IMRT plans were retrospectively generated from the 30 prostate cancer patients in three risk groups who received VMAT plans with a prescribed dose of 76 Gy in 38 fractions.

These cases included 10 low-risk patients, 10 intermediate-risk patients, and 10 high-risk patients. Next, the mean, maximum, and minimum doses and conformity and homogeneity indexes were evaluated for the PTV; the mean dose and V20 to V70 for OAR by using the dose-volume histograms of the VMAT and IMRT plans. Besides, the numbers and volume percentages of cold spots within PTVs and ROP regions were measured using in-house software. In addition, three-dimensional probabilistic distributions of cold spots were also generated using a centroid matching technique for visualization and analysis. Finally, the differences between the VMAT and IMRT plans were evaluated using two-sided paired Student' s t-test.

There was a statistically better dose conformity in the PTV, rectum, and bladder dose-sparing in VMAT plans compared to that in the IMRT plans, whereas VMAT plans had statistically worse target dose homogeneity and right and left femoral head dose-sparing than those of the IMRT plans. The averages ± standard deviations of the numbers of cold spots per PTV of all risk groups for the VMAT and IMRT plans were 0.21 ± 0.10 cm-3 and 0.24 ± 0.08 cm-3, respectively ($P = 0.158$). The average volume percentage of cold spots per PTV for the VMAT plans was 4.37 ± 2.68%, which was smaller than the 5.72 ± 1.84% observed for IMRT plans ($P = 0.007$). The numbers and volume percentage of cold spots per ROP for the VMAT plans did not significantly differ from those for the IMRT plans. The 3D PDs of the probability and distributions of cold spots in the VMAT and IMRT plans for the low, intermediate, high and all risk groups show that the cold spots are widely distributed throughout PTVs in both VMAT and IMRT plans. However, in the anterior-posterior (AP) and left-right (LR) views, most of the cold spots are distributed on the posterior and upper PTVs for both plans.

In conclusion, compared with IMRT plans, the VMAT plans achieved better PTV dose conformity, OAR dose-sparing, and smaller cold spots in the treatment of prostate cancer.