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I. Buzurovic
Thomas Jefferson University Hospitals

M. Werner-Wasik
Thomas Jefferson University Hospitals

T. Biswas
Thomas Jefferson University Hospitals

J. Galvin
Thomas Jefferson University Hospitals

A. Dicker
Thomas Jefferson University Hospitals

See next page for additional authors

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Dosimetric Evaluation of Tumor Tracking in 4D Radiotherapy

Authors
I. Buzurovic, M. Werner-Wasik, T. Biswas, J. Galvin, A. Dicker, Y. Yu, and T. Podder

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Dosimetric Evaluation of Tumor Tracking in 4D Radiotherapy

Buzurovic, I., Werner-Wasik, M., Biswas, T., Galvin, J., Dicker, A., Yu, Y., Podder, T.

Department of Radiation Oncology, Thomas Jefferson University Hospitals, Philadelphia, PA

Purpose

In some patients the tumors in lung, pancreas, liver, breast, and other organs move significantly during cardiac and breathing cycles. In this study we have investigated the dosimetric benefits of real-time tumor tracking for patients who were diagnosed with lung cancer.

Materials and Methods

The study includes the evaluation of dosimetric advantages of tumor motion tracking and the irradiation of normal lung and spinal cord. The dosimetric evaluation of tumor tracking was carried out on ten randomly selected patients who were scanned using 4D-CT technique. The 4D-CT phase reconstruction was performed using GE Advantage Workstation software, version AW 4.3_07. The 3D-CRT plans were generated using CMS-XiO4.4. Tissue heterogeneity was corrected for all plans. For each patient, eleven dosimetric plans were generated: ten plans for the target volumes contoured at ten breathing phases and one plan for the internal target volume (ITV) generated on average intensity projection (AvIP) studyset. The ITV was defined as a spatial sum of the gross target volumes (GTV) for each phase. The phasewise plans were compared to the clinically used ITV-AvIP plans in order to assess dosimetric effects of tumor tracking. The planning target volumes (PTV) were generated by adding 10mm margin around GTVs and ITV for both phase-wise plans and ITV-AvIP plans. To analyze data obtained from the dosimetric plans we compared dosimetric parameters including coverage of PTV (D99, D95, D50) volumes of normal lung receiving 5Gy, 13Gy, 20Gy, 30Gy dose (V5, V13, V20, V30) and D5 of spinal cord for AvIP-based plans with phase-wise tracked plans.

Results

Average PTV coverages for all plans were 91.6% of the prescribed dose (PD) for D99, 96.7% for D95 and 104.3% for D50. The average maximum dose was 110% of PD and the mean dose was 103.6% of PD. The 3D tumor motions for all investigated patients were more than 10mm. It was observed that average V5, V13, V20 and V30 with tracking technique were about 17.4%, 19.3%, 18.3% and 22.7% lower than the Vxs without tracking, respectively. Approximately 20% of healthy lung received 4-8Gy less dose when the tumor tracking technique was used. Spinal cord was the most important critical organ for the studied lung cases. Dose to the spinal cord (D5) with tracking technique was 17.5% lower compared to that of without tracking. D5 of the spinal cord received approximately 0.5-11 Gy less dose when tumor tracking technique was used; wide variations were observed due to differences in prescribed dose, tumor location and size.

Conclusion

Implementation of the active tracking and dynamic dose delivery techniques can potentially improve dose distribution of the tumor-volumes. This, in turn, will potentially improve the quality of patient treatment by minimizing irradiation to the healthy tissues, sparing critical organs and lowering the toxicities.