Purpose/Objective(s): The aim of this study is to provide a pre-clinical evaluation of a four-dimensional tracking radiotherapy (4DTRT) delivery to lung tumor using a prototype tracking system. Five patients who were treated with conventional three-dimensional conformal radiotherapy (3DCRT) were selected for the evaluation studies. The evaluation was carried on using films dosimetric analysis based-on QA dynamic phantom and using DVH analysis based on a 3D CRT and 4DTRT planning respectively.

Materials/Methods: The concept for four-dimensional tracking radiation therapy (4DTRT) can be shortly explained as to control the beam following the tumor motion. Currently in clinic the challenging is how to move the MLC leaves to form a tracking beam according to the motion of target. The key component of the evaluated 4DTRT system was TrackBeam. It consists of image processing tools and first-of-its-kind dual-layer micro MLC. DmMLC has two layers of orthogonal leaves providing advantages in speed and conformity when forming beam aperture for tracking. The TrackBeam was mounted to a Varian Linac and connected to a workstation which process the online MV fluence and controls each leaf’s motion. A Quasar dynamic phantom was used for radiographic film irradiation with 4DTRT and also 3DCRT. The phantom has a Gafchromatic film insert and a gold marker in the insert. The patient respiratory motion data was recorded during the 4D CT scanning and loaded to the dynamic phantom for QA propose. A 3DCRT and 4DTRT planning were developed with 180 cGy at 33 fraction based on 3D CT and dose volume histogram was compared.

Results: The respiratory motion cycles of the five patients were averaged at 3.31, 5.54, 2.67, 3.74 and 6.23 seconds per breathing. The synchronization of marker motion and the DmMLC leaf motion was achieved within less than 0.05 seconds. To evaluate the effect of real-time tumor tracking, a static tumor without motion was used as reference. The films analysis indicated that total 32.15% over the tolerance of 5% for 3DCRT and 7.12% of over the tolerance of 5% for 4DTRT compared to the static film respectively. The DVH comparisons indicate 4DTRT reduces significant dose to the Ring (expanding 2.5 cm from GTV) from 97.5% volume to 61.5% volume at V20 and reduces dose from 33.5 Gy to 11.5 Gy at 80% volume. 4DTRT also reduces considerable amount dose to the total lung from 28% volume to 18% volume at V20 and reduces dose from 35.2 Gy to 15.0 Gy at 20% volume.

Conclusions: We evaluated a 4DTRT DmMLC-based delivery and provided dosimetric analysis of radiographic films based on dynamic phantoms and DVH analysis based on patients 3DCRT and 4DTRT planning. Lung tumors are susceptible to motion due to respiration. The 4DTRT provided conformal coverage to mobile tumor and meanwhile limited the significant dose to the surrounding normal tissue.

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