Purpose: To determine a planning target volume (PTV) margin for lung cancer patients using a four-dimensional cone-beam CT (4D CBCT) acquired during volumetric modulated arc therapy (VMAT) treatment.

Methods: A VMAT plan for lung cancer patients was created by Pinnacle v9.0 (Philips) treatment planning system (TPS), where the gross target volume (GTVs) in each breathing phase was delineated by using 4D-planning CT scan (TOSHIBA and ANZAI). The VMAT treatment was performed with a stereotactic body frame after the registration using Elekta X-ray volume imaging (XVI) unit. Simultaneous cone-beam projection images were acquired for 3 or 4 fractions of 10 patients. The in-treatment 4D CBCT was reconstructed by dividing into four breathing phase bins. A total of 38 in-treatment 4D-CBCT sets were exported to Pinnacle TPS. The isocenter of in-treatment 4D CBCT was matched with that of 4D-planning CT. The tumor motion during treatment was manually tracked on in-treatment 4D CBCT, and the center-of-mass (COM) location of the tumor was estimated. Analyzing the tumor regions observed by in-treatment 4D CBCT, a PTV margin in our system was derived.

Results: The average difference in COM location of the tumor was less than 1mm for all directions, while the standard deviations (SD's) were about 1.3mm, 1.6mm, and 2.1mm for the lateral, the vertical, and the longitudinal directions, respectively. The large discrepancy more than 3mm was observed for one patient. The required PTV margin was about 3-4mm for the lateral and the vertical directions, whereas it was about 5mm for the longitudinal direction.

Conclusions: The uncertainties of the tumor motion caused by respiration were observed by in-treatment 4D CBCT images. It was feasible to determine the PTV margin from 4D volume images.

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