Purpose: Multiple anatomy optimization (MAO) utilizing deformable dose accumulation on entire 4DCT data sets is implemented to overcome ambiguity between optimal dose defined on a single anatomy and optimal accumulated dose resulting from dose delivery to moving and deforming anatomy.

Methods: Six lung cancer patients are planned using two methods of radiotherapy optimization: the internal target volume (ITV) envelope method and MAO, which simultaneously optimizes a single fluence for delivery to all 10 breathing phases such that the accumulated dose satisfies the plan objectives. Target dose is constrained to 70 Gy. The ITV-plan is optimized on a single breathing phase with the planning target volume defined as the ITV; the MAO target is the moving CTV. MAO is compared to single image ITV optimization based on the accumulated dose assuming equal monitor-units to each phase. Dose-volume differences between single image estimations and 10-image accumulation are examined.

Results: Single image optimal dose distributions overestimate target V70 by 4.2%±3.1% (average, one standard deviation) and in five of six cases ipsilateral lung V20 is underestimated (1.4%±0.9%). For these five cases, MAO increases V70 by 2.8%±2.5% (maximum of 6% increase in V70) and reduces ipsilateral lung V20 by up to 3% (average decrease of 1.2%±1.3%). Contralateral lung V20, esophagus V25, and heart V30 are also reduced by up to 5%, 3%, and 3%. For the sixth case, lung tumor motion is on the order of the dose voxel size (3mm), and MAO did not improve upon the ITV plan.

Conclusions: Dose-volume optimization on a stationary image does not ensure accumulated dose coverage to the moving CTV. Multiple anatomy optimization can remove dose ambiguity and improve plan quality.

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