Purpose: To demonstrate the feasibility of using probabilistic optimization for helical tomotherapy (HT) treatment planning of intrafraction moving targets: an alternative to motion management by active tracking.

Methods: Realistic but regular purely transverse elliptical motion was produced with the Washington University 4D Motion Phantom to supplement previous work that contained either transverse and longitudinal or just longitudinal motions with varying amount of randomness and drifts. Dose perturbations due to motion were measured with Gafchromatic EBT film. A small (12cm diameter, 12 cm long) Virtual WaterTM cylindrical phantom is used in a Hi-Art IITM (TomoTherapy Inc., Madison, WI) HT device. The treatment plan consists of a 9 cm ring target (98% gets the prescribed dose) with a 4 cm diameter central avoidance region (gets half the prescribed dose on average) for 9 cm along the length of the cylinder.

Results: The transverse motion needs to be much larger than average transverse respiratory motions for lung tumors for the motion to cause unacceptable blurring. This and other studies demonstrate that HT is robust to breathing motion interference with the beamlet modulation, but care must be taken in the longitudinal direction for irregular breathing with a low frequency drift that interferes with the couch motion. Within the target, less than a 1% dose perturbation is observed between $0.10 < (\text{gantry period})/(\text{breathing period}) < 10$.

Conclusions: With reasonable care to approximately regularize the patient's breathing, the dose distribution exhibits a dominantly 'blurred' response to the motion, so a single motion probability distribution function (pdf) can approximate the respiratory motion well enough to enable the use of probabilistic optimization. HT's delivery over multiple gantry rotations and patient breathing cycles enables sufficient dose smoothing for probabilistic optimization to apply to hypofractionated HT deliveries.

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