Purpose: Accurate tumor tracking, especially for lung cancer, remains a challenge ineffectively addressed. Many strategies including respiratory gating and fiducial implanting alleviate the problem to different extents however they are sub-optimal due to indirect tracking. To track the tumor itself, the concept of Emission Guided Radiation therapy (EGRT) was recently proposed. This work serves to demonstrate the feasibility of the EGRT concept within the context of lung cancer treatment.

Methods: EGRT is based on the physics principle that lines of response (LOR's) from positron emission events can define the lines of radiation projection passing through the emission sites. It enlightens the design of a radiation delivery system consisting of a linac and PET detectors on a fast rotating closed-ring gantry. When treating radiotracer administrated patients, PET detectors collect LOR's from tumor uptake sites and the linac responds simultaneously with beamlets of radiation along the same LOR paths. Accurate direct tumor tracking can automatically be achieved with real-time responses. To validate the EGRT concept, a treatment scheme is designed and implemented for the 4D XCAT phantom with a lung tumor. A conventional treatment is modeled for comparison. Attenuation correction is also implemented in EGRT. The emission process is simulated by Geant4 Application for Tomographic Emission package (GATE) and linac dose delivery is simulated using a voxel-based Monte Carlo algorithm (VMC++).

Results: EGRT, with or without attenuation correction, achieves over 25% and 40% relative dose increase to 100% and 50% of the tumor volume respectively compared to the conventional treatment with all cases normalized to have the same integral dose to lung. Attenuation correction helps achieve a better dose performance. Dose-peaking in the tumor volume is observed in EGRT, demonstrating automatic tumor tracking.

Conclusions: As a new radiation therapy modality with inherent tumor tracking, EGRT has the potential to substantially improve radiation therapy for lung cancer.

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