Purpose: Deformable image registration (DIR) allows modeling of liver tumors on respiratory correlated (4D) imaging. The mid-position CT was reconstructed for liver SBRT plans using DIR, and the potential for dose-escalation was investigated.

Methods: Thirty patients were planned clinically with IMRT for 27-48 Gy in 6 fractions on static exhale 4DCT with PTVs encompassing the breathing amplitude. For research, exhale 4DCT was deformed to the inhale 4DCT using biomechanical DIR. The mid-position CT was created by applying a percentage (the time-averaged normalized position between exhale and inhale calculated from daily 4D cone-beam CT) to this deformation map, assuming a linear trajectory. A probability-based PTV margin, using patient-specific breathing amplitude from DIR of 4DCT, was created around the GTV on the mid-position CT where IMRT was re-optimized. Dose was maximally escalated according to clinical protocol (e.g. liver NTCP <5%). The 4D predicted breathing dose was accumulated by interpolating the elements' positions at exhale, mid-position and inhale onto the respective dose matrices (weighted by time spent nearest each matrix) then summed.

Results: Compared the exhale plans, the GTV-to-PTV volume decreased on the mid-position plans by a mean of 31% (p<0.01, range: 24-38%). Static re-planning on the mid-position CT decreased the mean effective liver volume by 7% (p=0.032), enabling escalation of the nominal prescribed dose in 80% of patients of 6-12 Gy. Reconstruction of the 4D predicted breathing dose resulted in a mean increase of 6.7 Gy (p<0.01, maximum increase of 15.0 Gy) in mean GTV dose for the mid-position versus the exhale plan. For the mid-position plan, the minimum 0.5 cm³ GTV dose received 100% of the prescription in the 4D distribution.

Conclusions: Liver SBRT Planning at the mean respiratory position enables PTV reduction and a mean dose escalation of 6.7 Gy, potentially improving local control.

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