Setup variations and breathing-induced movements create differences between calculated and delivered doses for intra-hepatic lesions. We recalculated CTV and normal liver doses for 41 patients to include these effects. Initial 3D dose calculations based on pretreatment CT scans taken with voluntary breath-hold at normal exhale were convolved with 3-D anisotropic probability distribution functions reflecting population measurements of position variation. The convolution also included a distribution function (1-D; inferior-superior direction only) representing the asymmetric temporal pattern (biased towards exhale, based on population measurements) of a typical breathing cycle, scaled in amplitude for each patient. Following convolution, the minimum CTV dose met or exceeded the minimum PTV dose from the static plan in all but one case; indicating adequate PTV design. However, clinically relevant and statistically significant (at 95% confidence level) increases (decreases) in NTCP from values computed for the static cases occurred for tumors located toward the bottom (top) of the liver; as predicted for these patients scanned at exhale. The change in NTCP (from a nominal 20%) ranged from +17% to -12% (average magnitude change 3.8% (σ 3.6%)). Changes in prescription dose required to restore the original 20% NTCP ranged from -5 Gy to +8 Gy (average magnitude change 1.7 Gy (σ 1.9 Gy)). Although the PTV concept can ensure adequate CTV coverage, the doses to normal liver are incorrectly modeled without including patient related geometric uncertainties.

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