Residual motion mitigation in scanned carbon ion beam therapy of liver tumors using enlarged pencil beam overlap.

Interplay effects may limit the applicability of scanned ion beam therapy for moving tumors even if the motion amplitude is reduced by techniques such as gating or abdominal compression (AC). We investigate the potential of enhanced pencil beam overlap to mitigate residual motion interplay effects in scanned ion beam therapy. Eight patients with hepato cellular carcinoma were selected who were either treated under AC (5 clinical target volumes (CTVs)) or with gating (6 CTVs). We performed 4D dose calculations for treatment plans with variable beam parameters (lateral raster spacing, beam full-width-at-half-maximum (FWHM), iso-energy slice spacing, gating window (GW)) and assessed under- and overdose (V95 and V107), dose homogeneity (HI=D5-D95), and dose volume histograms. The influence of the beam parameters on HI was studied by multivariate regression models. Motion amplitude and FWHM had the largest impact on dose homogeneity, while decreased iso-energy slice spacing and lateral raster spacing had a much smaller or no significant effect, respectively. The multivariate regression models including FWHM, motion amplitude, and IES-spacing explained 86%, 42%, and 71% of the observed variance for AC, 30% and 50% GW, respectively. Residual motion in scanned carbon ion therapy of liver
tumors can lead to considerable dose heterogeneities. Using an increased beam spot size dose degradation can be significantly mitigated. Especially for large tumors, increasing the beam spot size is an efficient motion mitigation option readily available at most scanning facilities.

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