locations; Dose to the prostate and pelvic node CTVs, rectum, bladder and femoral heads were calculated and presented for the total 20 plan scenarios of each patient.

Results: For bony matching, prostate CTV dose degradation was prominent for interfraction prostate motion beyond prostate PTV margins. Potential prostate intrafraction motion would further degrade the prostate CTV coverage. Lymph node CTV dose coverages were not affected; for seed matching, dose degradation of pelvic lymph node CTV was prominent for interfraction prostate motion beyond pelvic node PTV margins. Dose coverage to prostate CTV were comparable to original treatment plans. For the seed matching image guidance, there were large dose variations to the rectum, bladder and femoral head among different prostate interfraction motion datasets. For the bony matching image guidance, there were large dose variations only to the rectum among different prostate interfraction motion datasets.

Conclusion: Prostate interfraction motion from pelvic lymph node has significant impact on prostate and lymph node CTVs coverage. Due to this motion, different image guidance approach affect the target coverage and dose to OARs in a different manner.

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Tumor Motion and Dosimetry Variability Based on 4DMRI in Comparison with 4DCT

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Purpose/Objective(s): To evaluate the variations of respiratory-induced tumor and organ motion of lung cancer patients, internal tumor volume (ITV) difference based on 4DCT and 4DMRI simulations, and tumor planning dose coverage of 4DMRI-ITV using a clinical VMAT plan based on 4DCT-ITV.

Materials/Methods: Respiratory-correlated (RC) and time-resolved (TR) 4DMRI were applied to compare the tumor/organ motion variability during free breathing at different time points of simulation with 4DCT, under an IRB-approved protocol. Eight lung cancer patients (10 lesions) were recruited and scanned with both clinical 4DCT and research 4DMRI on the same simulation day within about 2 hours. The same patient immobilization device was used for both 4D scans in free breathing. The gross tumor volumes (GTV) in the 10 respiratory states were delineated by a radiation oncologist, the GTV motion trajectories were analyzed, and the ITV was calculated. The 4DCT and 4DMRI images were registered to the planning CT and the same patient coordinate systems were shared. The clinical VMAT plans of these patients based on the ITV from 4DCT were modified by swapping the ITV with that from 4DMRI, the 3D dose was recalculated with the same leave sequence and monitor units (MUs), and the planning tumor volume (PTV = ITV + 5mm) coverage was evaluated using the dose-volume histogram (DVH). The ITV was swapped both directly (simulating setup on the bone) and with further alignment respective to their centers (simulating setup on the tumor). The tumor motion range was also evaluated with time-resolved (TR) 4DMRI, which captures multi-breath motion, providing extreme motion scenarios.

Results: The motion of the GTV varies from -44% to 177% from 4DCT to 4DMRI, resulting in a GTV motion variation of -8.2 mm to 6.3 mm, compared with the motion in 4DCT. The mean GTV from RC-4DMRI and 4DCT are similar on average. In RC-4DMRI, PTV coverage is severely under dosed and the plan is compromised when the ITV is enlarged due to a larger volume motion in 4DMRI. When the 4DCT-ITV is directly replaced by the 4DMRI-ITV, severe under-dosing of the PTV is observed with D95 = 85±11% (if setup on bony landmarks without tumor alignment), however, if the 4DCT-ITV is replaced by the aligned 4DMRI-ITV (if setup on the tumor position), under-dosing of the PTV is observed with D95 = 94±8.4%. The original clinical VMAT plan is used as a control with the plan PTV coverage with D95 = 99±2.1%. Using TR-4DMRI multi-breathing motion monitoring, a much larger tumor motion variation is observed, containing many more extremes than the snapshot RC-4DMRI or 4DCT images.

Conclusion: This study illustrates that the ITV can vary substantially at different time points. When the ITV is underestimated, the tumor dose coverage can be severely compromised from the planning point of view, whereas if the ITV is overestimated, the OAR receives more dose unnecessarily, causing a higher rick for toxicity. Further investigation is ongoing to accurately estimate the delivered dose with multi-breath motion history.

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Prediction of LIVER Toxicity with Stereotactic Body Radiotherapy: A Dosimetric Analysis

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Purpose/Objective(s): To further evaluate the corresponding dosimetric factors with the liver toxicity following stereotactic body radiation therapy (SBRT).

Materials/Methods: Between 2015-2018, 76 patients with liver tumor (primary or metastases) treated with SBRT were reviewed based on dosimetric factors and liver function tests. The reference point was contoured that the main portal ven divided in the liver hilum into the left portal vein branch and the right portal vein branch on the contrast enhanced simulation CT scan set. Two different isotropic expansions from the reference point were generated as 2(zone 1) and 4 cm(zon 2). Out of zone 2 was defined as zone 3 in the rest of liver. The radiation doses of each zones were converted BED 10 and tested for correlation with liver functon tests which were obtained during follow up. Liver functions were assessed with Drug-Induced Liver Injury Network (DILIN) grading system for liver disease severity.

Results: Median follow up was 10 months (range 6-36 months). Four of 76 patients were diagnosed with primary liver tumor(Hepatocellulary ca), rest of 72 patients were diagnosed secondary tumor(kolorectal 30, lung 21, breast 13, other 8). Median age was 64(range 48-76). Sixteen of patients have grade 1 liver disfunction, 4 of patients have grade 2 toxicity after radiotherapy. The prescription doses were 45-60 Gy in 3-5 fractions. Median tumor volume was 24.4 cc(range 8.5-39.9 cc). The volume of received 20 Gy ($V_{BED10}20$) more than 50 cc in the zone 2, was significantly correlated with grade 1 toxicity($p=0.03$).

Conclusion: These results suggest that the volume of received 20 Gy more than 50 cc dose to 2 cm expansion from reference point in the liver may be associated with acute liver enzyme abnormality. This dosimetric parameter has potential implications for future liver SBRT studies.

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