JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING
EASTERN TIME [GMT-4]

A beam-angle-selection method to improve inter-fraction motion robustness for lung tumor irradiation with passive proton scattering

Yawei Zhang[1,2], Meng Wei Ho[1,2], Zuofeng Li[1,2]

[1]University of Florida Health Proton Therapy Institute, 2015 N Jefferson St, Jacksonville, FL 32206
[2]Department of Radiation Oncology, University of Florida, 2000 SW Archer Rd, Gainesville, FL 32061

PURPOSE: to develop a method to identify patient-specific robust proton beam angles for lung tumor irradiation by investigating the association between water equivalent thickness (WET) variation and inter-fraction motion-induced target dose degradation.

MEHTODS: using 3-dimencomputed tomography (3D-CT) images, the impact of WET variations on target dose coverage for a series of coplanar proton beams was evaluated for four lung cancer patients. Using ray tracing, WET maps, or WET baseline, were estimated for the internal target volume (ITV) at every 5° gantry interval in the axial plane. After calculating the WET baseline, the planning CT was shifted 5 mm in each anterior-posterior (AP), superior-inferior (SI), and left-right (LR) direction, yielding a total of 6 shifted CTs, and differential WET maps between the planning CT and each shifted CT were calculated. Target dose differences were associated with the average WET change between the original planning CT and the shifted CTs for all beam rays across the 360° gantry rotation angle. Target and OAR dose metrics in the ΔWET-guided plans were compared with those of the clinical plans.

RESULTS: The WET variation maps showed areas of both high and low WET variations, with overall similar patterns yet individual differences reflecting differences in tumor position. The coplanar plans showed a strong association between WET changes and ITV dose reductions for all 4 patients investigated in this study. Target dose coverage was more stable with the ΔWET-guided plan while OAR doses were comparable to the clinical plan.

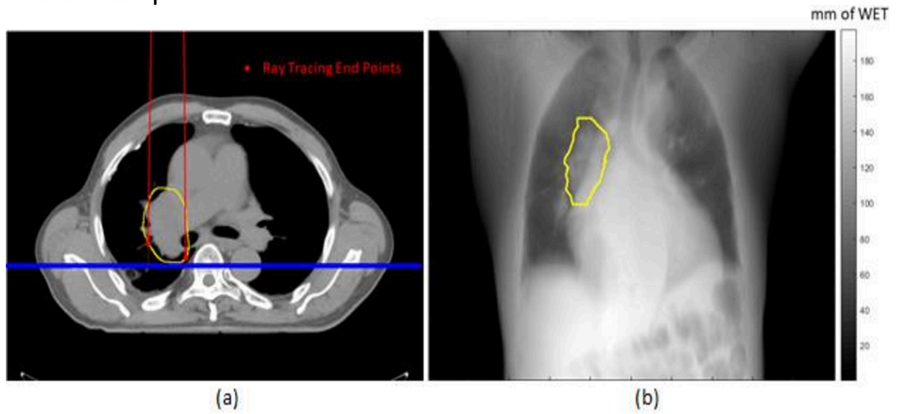

Figure 1. Conceptual illustration of the WET map calculation used in this study. (a) The ITV structure is shown contoured by the yellow line. The beam angle was at 0˚; the red dots represent the end voxels of each ray tracing; the blue plane was defined to accumulate the WET map. (b) The WET map accumulated on the blue plane. A ray passing through the ITV will stop at the distal end of the ITV; otherwise, it will stop at the virtual detector defined by the blue plane. Note that only the WET in the ITV region was included in the statistics analysis.

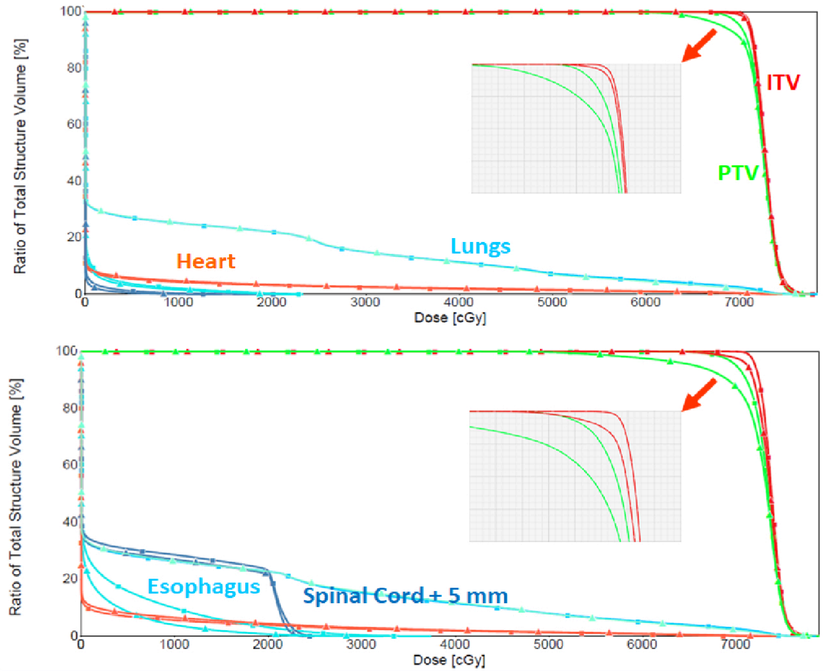

Figure 2. The ΔWET-guided plan (top) DVH curves before and after the shift. DVH curves from the original plan (bottom) before and after the shift from the original clinical plan are shown for comparison.

CONCLUSIONS: The WET variation maps have been used in this pilot study to identify proton beam angles that are either sensitive or robust to WET changes in proton passive scattering. This work demonstrates the feasibility of using WET variation maps to assist the planner in inter-fraction motion-robust proton beam angle selection.

REFERENCES: [1] O. Casares-Magaz, J. Toftegaard, L.P. Muren, J.F. Kallehauge, N. Bassler, P.R. Poulsen, J.B. Petersen, A method for selection of beam angles robust to intra-fractional motion in proton therapy of lung cancer, Acta Oncol, 53 (2014) 1058-1063.
[2] J.E. Matney, P.C. Park, H. Li, L.E. Court, X.R. Zhu, L. Dong, W. Liu, R. Mohan, Perturbation of water-equivalent thickness as a surrogate for respiratory motion in proton therapy, J Appl Clin Med Phys, 17 (2016) 368-378.

CONTACT INFORMATION: yzhang@floridaproton.org