Respiratory Tumor Motion Reduction using an Abdominal Arc Compression Device

Apiradee Srisuthep1,2, Jayashree Kalpathy-Cramer3, Warren D'Souza4, Martin Fuss1, 1Radiation Medicine, and 3Medical Informatics and Clinical Epidemiology, Oregon Health & Science University, Portland, OR, USA, 2Radiation Oncology, Bhumibol Adulyadej Hospital, Bangkok, Thailand; 4Radiation Oncology, University of Maryland, Baltimore, MD, USA

Purpose:
To investigate how the use of an abdominal arc compression device impacts on respiration-induced liver motion as assessed by volumetric 4DCT imaging.

Methods:
Fifteen patients with with 21 different tumor locations have undergone simulation for a course of Stereotactic Body Radiation Therapy (SBRT) treatment using a novel abdominal arc compression device adapted to a clinically established double-vacuum whole body immobilization device (BodyFix, Medical Intelligence). The compression device consists of a carbon fiber arc, and a choice of abdomen compression plates that are placed caudal to the xyphoid on the anterior abdomen with the intent to restrict liver respiration motion. All patients underwent 4DCT imaging with and without the compression device in place; when no abdominal compression was used, the double vacuum was still utilized. Target volumes were delineated in free breathing (FB) scans, 10 respiratory phases, and maximum-intensity projection (MIP) reconstructions. We assessed the range of tumor motion with and without abdominal compression in place, and compared planning target volumes typically used for SBRT planning (PTVFB: GTVFB + 5 mm axial, 10 mm cranio-caudal; PTVMIP: internal target volume, ITVMIP + 5 mm). We also assessed patient tolerance.

Results:
Among the patients studied, only 1 patient rejected the use of the arc compression for SBRT delivery. While the pattern of motion remained unchanged in 19/21 cases studied, the range of motion differed significantly with a smaller range of target motion observed in 4DCT studies acquired with arc compression (p=0.002, and p=0.02 for cranio-caudal, and anterio-posterior motion, respectively). PTVs derived from both GTVFB and ITV MIP target volumes were smaller in arc compression studies by up to 35.4% (mean PTVFB reduction 6.6%, with 18/21 studies having a smaller PTVFB; mean PTVMIP reduction 10.6%, with 18/21 studies showing a smaller PTVMIP; maximum PTVMIP increase observed was 4.3%).

Conclusion:
The studied addition of an arc abdominal compression device resulted in reduced liver tumor respiration-induced motion in the majority of patients. PTVs for planning were consequently smaller in volume by up to 35.4%. Based on pre-treatment comparative assessment, 17 tumors in 12 patients were treated using the abdominal arc compression device (1 patient refused despite assessed PTV MIP reduction of 24%). The observed discrepancies between FB studies derived PTV, and PTV derived from ITV MIP that fully incorporate the respiration motion envelope of a tumor, indicate the necessity to incorporate more advanced volumetric imaging tools when assessing the clinical impact of novel immobilization devices.