Purpose: Three methods of calculating ventilation from 4D CT image sets have been explored by several research groups. This study is to investigate the differences of these three local ventilation calculations.

Methods: Optical flow (OF) deformable image registration of the normal end expiration and inspiration phases of 4D-CT images was used to correlate the voxels between the two phases. The OF was validated using a 4D pixel-based and point-validated breathing thorax model, consisting of a 4D-CT image data set along with associated landmarks. Ventilation derived from 4D-CTs from 20 esophageal patients were retrospectively analyzed. Differences between the ventilation images generated by three methods, the Jacobian, the DeltaV, and the HU, were examined on a voxel-to-voxel basis. The Jacobian method uses the first derivative of the deformation field to approximate the change in volume of voxels. The DeltaV method directly calculates the volume change. The HU method uses the change in Houndsfield Units (HUs) of corresponding voxels to calculate ventilation.

Results: The target registration error (TRE) for the deformable image registration was an average of 1.6±0.68 mm and maximum of 3.1 mm. Average difference between the DeltaV and the Jacobian ventilation as a percentage of the maximum ventilation value was 0.51±0.3% (range 0.33% to 1.32%). Average difference between the DeltaV and HU ventilation was 2.4±4.5 % (range 0.4% to 19.2 %). A small number of voxels show significant differences. We speculate that the larger differences were due to some image registration variances. Regions of highest and lowest ventilation matched well for all methods.

Conclusions: Highs and lows in ventilation were more pronounced in the DeltaV method compared to the Jacobian. In general the differences between the two ventilation methods were small. However, the differences between the DeltaV and the HU methods were considerably larger.