AbstractID: 2873 Title: A 5-dimensional breathing motion model for radiation therapy

Purpose:
To develop a mathematical formalism that models breathing motion of lung tumors and normal organs for radiation therapy treatment planning.

Method and Materials:
The model is based on the assumption that breathing motion is caused by interactions between muscle-induced air-pressure distributions and the supporting structure of lung tissues. For quiet respiration, the motion of each object within the lungs is broken down into two independent components. First, the positions in the steady-state (zero airflow) are modeled as a function of breathing depth, parameterized by the tidal volume v. As the patient breaths deeper, the objects move farther along their trajectories. Second, the hysteresis commonly observed in lung motion is due to local pressure imbalances caused during the dynamic act of breathing and is assumed to be a deviation from the zero-flow trajectory. The hysteresis component is assumed to be proportional to local pressure imbalances which are proportional to the airflow at the patient's mouth, so this component is modeled as a function of airflow f=dv/dt. The motion of any internal object, therefore, has five degrees-of-freedom; the three Cartesian coordinates of the object during a user-selected reference breathing phase, the tidal volume and the airflow.

Results:
The model was applied using a linear mathematical form used with measured patient breathing-trajectory data of 76 tracked objects in 4 patients, which data was acquired using 4DCT and concurrent spirometry-measured tidal volume. The tracked-object displacement was a linear combination of two independent vectors with lengths proportional to the tidal volume and airflow. The patient data showed that the mathematical formalism was capable of modeling the objects' motion within 10% and 15% of the objects' maximum extent for 73% and 95% of the objects, respectively.

Conclusion:
This 5-dimensional model provides a method for mapping breathing motion and is being extended to more clinical datasets.