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Cluster-specific small airway modeling for imaging-based CFD analysis of pulmonary air flow and particle deposition in COPD smokers[1]
BABAK HAGHIGHI, JIWOONG CHOI, Univ of Iowa, SANGHUN CHOI, Kyungpook National University, Daegu, South Korea, ERIC A HOFFMAN, CHING-LONG LIN, Univ of Iowa — Accurate modeling of small airway diameters in patients with chronic obstructive pulmonary disease (COPD) is a crucial step toward patient-specific CFD simulations of regional airflow and particle transport. We proposed to use computed tomography (CT) imaging-based cluster membership to identify structural characteristics of airways in each cluster and use them to develop cluster-specific airway diameter models. We analyzed 284 COPD smokers with airflow limitation, and 69 healthy controls. We used multiscale imaging-based cluster analysis (MICA) to classify smokers into 4 clusters. With representative cluster patients and healthy controls, we performed multiple regressions to quantify variation of airway diameters by generation as well as by cluster. The cluster 2 and 4 showed more diameter decrease as generation increases than other clusters. The cluster 4 had more rapid decreases of airway diameters in the upper lobes, while cluster 2 in the lower lobes. We then used these regression models to estimate airway diameters in CT unresolved regions to obtain pressure-volume hysteresis curves using a 1D resistance model. These 1D flow solutions can be used to provide the patient-specific boundary conditions for 3D CFD simulations in COPD patients.

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