Visualizing Every Breath You Take

Magnetic resonance images provide view of complex airflow in mammalian lungs

Airflow patterns in the lung not only determine how well you breathe but also how inhaled materials like airborne pollutants or aerosolized drugs are distributed inside the human body. At the Department of Energy's EMSL, researchers from Pacific Northwest National Laboratory and the University of Utah have pioneered a new magnetic resonance imaging (MRI) method for visualizing inhaled airflow patterns. The method uses hyperpolarized ^{3}He gas as an inert tracer for visualizing inhaled air speed and direction at each location within the complex, three-dimensional airways of pulmonary anatomy.

Researchers at EMSL measured 3D airflow patterns in laboratory rats using MRI resources.

Published results highlighted on the cover of the *Journal of Magnetic Resonance* reveal a common aerodynamic phenomenon known as air streaming. This was observed as a thin layer of high speed gas localized along the outside radius of curvature in the trachea. The results also show, for the first time, how air speed is reduced as flowing gas branches along different paths to fill each of the rat's five lung lobes. This was seen as a transition from high gas speed to a slower flow rate.

Scientific impact: Researchers are using EMSL's ^{3}He MRI in conjunction with its advanced computing resources to develop and test state-of-the art computer models of inhaled airflow. These models are important not only for predicting where inhaled materials are deposited in the lung, but also for understanding how their fate ultimately affects human health. This work is part of EMSL's ongoing efforts to predict biological functions from molecular and chemical data.

Societal impact: Biomedical applications of ^{3}He-flow-MRI range from improving inhaled drug delivery to monitoring therapeutic response in patients with breathing disorders like asthma or Chronic Obstructive Pulmonary Disease. The ability to measure alterations in regional lung ventilation also provides a unique opportunity for assessing the subtle effects of inhaled pollutants, and for improving assessment of their potential health risks. EMSL users are exploiting this to help understand the risks associated with common pesticides of interest to the Environmental Protection Agency. They have also begun to exploit ^{3}He-flow-MRI for visualizing electrochemistry in operating fuel cells as part of efforts to improve operating efficiency and reliability.

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Reference: Minard KR, RE Jacob, G Laicher, DR Einstein, AP Kuprat, and RA Corley. 2008. "MR Imaging of Apparent ^{3}He Gas Transport in Narrow Pipes and Rodent Airways." *Journal of Magnetic Resonance* 194(2):182-191.

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