QUANTITATIVE ASSESSMENT OF DEPOSITION PATTERNS OF INHALED PARTICULATE MATTER BY MRI

M. Scadeng[1], E. C. Breen[2], G. K. Prisk[2], D. J. Dubowitz[1], and C. Darquenne[2]
[1]Radiology, UCSD, San Diego, CA, United States, [2]Medicine, UCSD, San Diego, CA, United States

Introduction

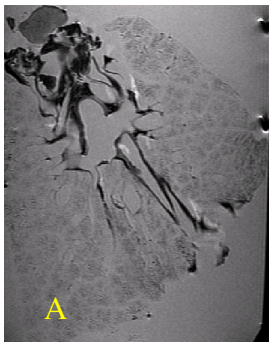
Exposure to airborne particulate matter and its implications in human health are a major concern as more evidence links air pollution with morbidity and mortality. Understanding the fate of aerosols in the human lung is also important in medical applications such as inhalation drug therapy, and threats of biological warfare.
Detailed non-invasive studies of peripheral aerosol deposition are almost impossible in humans, therefore computational and animal models are primarily used. Recently we have shown that high field, high spatial resolution MRI (50-100 µm) can be used to visualize rodent lung structure [1], making it is possible to directly determine the location of individual micron-sized particles of iron oxide in tissue. We have developed a technique to measure the size dependant deposition patterns of inhaled iron-labeled particles of known sizes in the respirable range using MRI.

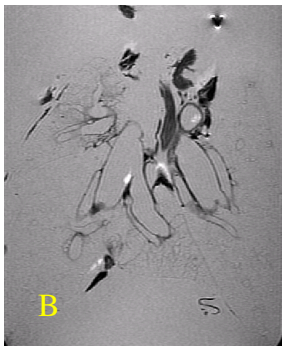
Methods

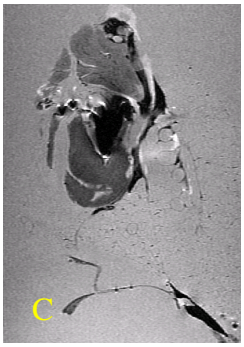
Ferric oxide particles of 0.9 and 2.6 µm (diameter) were selected as being in the freely respirable range (i.e. capable of being deposited beyond the upper airway). The particles were aerosolized and delivered in a controlled manner to anethetised tracheotomized, ventilated rats over a 20 min. period. The animals were then euthanised (pentobarbitol), the lungs were inflated to a pressure of 15cm water, and perfusion fixed via the pulmonmary artery initially with PBS (to removal all blood from the lung vasculature) and then with 3% gluteralhehyde, at a pressure of 20cm water. The lungs were removed and degased in PBS under gentle vacuum for 2 days. Lung T_2 measurements for different particle sizes were made at 3T (TR/TE=3000/11-200ms). High resolution imaging was performed at 7T scanner (GE, Milwaukee) using a heavily T_2-weighted spin echo sequence TR/TE=4000/30, resolution=80x80x200 µm.

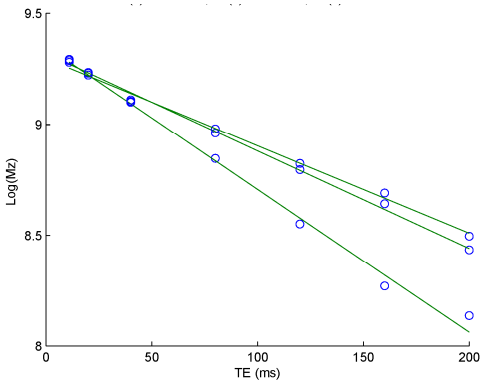
Results

On high resolution imaging at 7T the smaller 0.9 µm particles were seen distributed evenly throughout the pulmonary parenchyma (A). The 2.6 µm particles primarily outlined the large airways with only a small amount of deposition seen in the parenchyma (B) relative to control lungs (C). T_2 measurements of peripheral parenchymal ROI's mirrored the high-resolution MRI iron distribution findings: Lung T_2: 0.9 µm particles = 155.1ms, 2.6 µm = 227.6ms, control = 254.1.1ms.









Conclusion

The technique allows visualization and quantitation of the distribution of aerosolized particles in the lung periphery. This provides an outcome measure for studying the pathophysiological mechanisms that govern the fate of aerosols and airborne pollutant exposure in the lung. The technique is applicable to the study of both normal and diseased lung (e.g. asthma or emphysema), and could aid the rational design of inhalation therapy.

Refs: 1. Scadeng M, Rossiter HB, Dubowitz DJ, Breen EC. High-resolution three-dimensional magnetic resonance imaging of mouse lung in situ. Invest Radiol. 2007;42:50-7. Supported by: NSBRI/NASA #TD00701, NIH R21 RR021919.