Hyperpolarized gas delivery to subject in MRI scanner for enhanced pulmonary diagnostics and disease progression monitoring

Device for the optimal mixing and delivery of MRI gaseous contrast agents

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Problem
Gaseous contrast agents and, more specifically, hyperpolarized (HP) noble gases, such as helium-3 and xenon-129, are used for investigational imaging of respiratory gas in lungs by MRI for the purpose of assessing regional lung function. The ultimate goals of such imaging methods include diagnosis, evaluation, and monitoring progression of respiratory diseases, as well as evaluating the efficacy of therapeutic interventions. The pulmonary diseases that can benefit from such an imaging modality include obstructive lung diseases (e.g. emphysema, chronic bronchitis, and asthma) and interstitial lung diseases (e.g. cystic fibrosis and idiopathic pulmonary fibrosis).

Recently, sophisticated imaging methodologies have been developed based on HP gas MRI technology to extract richer and more valuable information about lung function. At the same time, these new technologies impose certain requirements on the delivery pattern and mixture content of the HP gas during the imaging session – requirements that have not yet been met. HP gases depolarize very rapidly in vivo due to interaction with other respiratory gas components and airway tissue. Depolarization of the HP gas limits the obtainable signal in MR images and has a negative effect on measurements accuracy.

Solution
To address this concern, researchers at the University of Pennsylvania have developed systems and methods that permit real-time mixing of HP gas and oxygen in order to prevent premature depolarization of the contrast gas while maintaining proper gas levels (FiO2) for the subject’s safety. The developed system further permits control of the delivered tidal volume (VT) at a specific level in order to image the lung at the same inflation volume over the sequence of several breaths, both for physiological stability and for matching images from different breaths; i.e. image co-registration.

Advantage
• Ensures that the same proportional amount of HP gas and oxygen is flowing into the lungs throughout the respiratory cycle
• Ensures proper mixing of gases
• Delivers highly accurate quantitative imaging of fractional ventilation in human subjects
• Allows the subject to maintain a respiratory pattern very similar to normal breathing